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ABSTRACT

Abstracts of most of the papers presented at the 56th Annual Meeting of the National Association for Research in Science Teaching (NARST) have been collected in this publication. Papers focus on such areas as student and teacher characteristics, student and teacher attitudes, science curriculum, science instruction, preservice and inservice teacher education, learning, achievement, science education research in foreign countries, cognitive development, problem solving, reasoning, neuroscience and science education, concept teaching and learning, energy education, environmental education, instructional uses of computers, and science education research methodology and techniques. (JN)

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FOR

RESEARCH IN SCIENCE TEACHING

Dallas Hilton

April 5 - 8, 1983

ABSTRACTS OF PRESENTED PAPERS
at
56TH ANNUAL NARST CONFERENCE
1983

ERIC Clearinghouse for Science, Mathematics,
and Environmental Education
The Ohio State University
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Columbus, Ohio 43212

PREFACE

The ERIC Clearinghouse for Science, Mathematics and Environmental Education has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the 56th annual conference at The Dallas Hilton, Dallas, Texas, April 5-8, 1983.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC staff to provide a general format for the abstracts. Special recognition should be given to Dr. Ann C. Howe and the NARST Program Committee who obtained the abstracts and organized the program.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Resources in Education, Current Index to Journals in Education, and other publications of the ERIC system.

Arthur L. White and Patricia E. Blosser
Editors

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Session A-1

AN INVESTIGATION OF THE ATTITUDES AND PERCEPTIONS OF JUNIOR HIGH SCHOOL STUDENTS TOWARD SCIENCE COURSES

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The primary objectives of the study were to determine factors influencing the attitudes of junior high school students toward science courses, and to identify science teaching practices that can enable teachers to motivate their students.

The subjects were 226 seventh grade students and 217 ninth grade students enrolled in three urban and three suburban schools in Michigan. The teachers of these students also participated in the study.

Six instruments were used to collect data: *Attitude Toward Science Courses*, *Attitude Toward School*, *Student Science Classroom Activities*, *Teacher Science Classroom Activities*, *Science Knowledge and Person-Environment Fit*.

The results indicated that seventh grade students were *significantly more motivated* toward school and toward science courses than were ninth grade students. Although attitude toward school was found to have a dominant effect on attitude toward science courses, the former variable *did not* account for *all* the variation in attitude toward science courses. A substantial portion of the variance in attitude toward science courses was explained by the variations in students' perception, person, science achievement scores, and the school which the students attended. Urban seventh grade students enrolled in classrooms where hands-on science was effectively taught were found to have *significantly more positive attitudes* than their suburban counterpart taking traditional science courses. Science courses *per se* were found to have *very little effect* on attitudes. Student perceptions of science classroom teaching behaviors *were significantly different* from the way teachers perceived themselves teaching. Science teaching in ninth grade classrooms *was significantly more teacher and textbook oriented* than in seventh grade classrooms. The boys in the sample were significantly more interested in the manipulation of laboratory materials and equipment than were the girls.

On the basis of the findings of this study it is suggested that manipulative science and student-centered science instruction should be encouraged in junior high science classrooms in order to stimulate the development of positive attitudes.

Session A-1

RELATIONSHIPS AMONG ATTITUDE, MOTIVATION AND ACHIEVEMENT OF ABILITY-GROUPED, SEVENTH GRADE, LIFE SCIENCE STUDENTS

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Seventh-grade life science students assigned to different ability groups from four junior high schools were studied to determine if their attitude toward science and achievement in science were different. Results indicated that level of ability group and time of testing were significantly related achievement and that males achieved higher than did females at all levels. Advanced ability groups were significantly more positively motivated toward science than all other ability groups and that females were more highly motivated than males. As the school year progressed, motivation toward science decreased. Males had a more positive attitude toward science than had females and, as the school year progressed, all students' attitudes declined. The advanced ability group had the most positive attitude toward science.

Session A-1

PEER AND CLASSROOM INFLUENCES ON ATTITUDES TOWARD SCIENCE AND ACHIEVEMENT IN SCIENCE AMONG TENTH GRADE BIOLOGY STUDENTS

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The classroom is the basic structural unit of our educational system. This learning environment is an area where a large number of interactions occur between students, teachers, peers, physical environment and curriculum. These interactions create a climate that affects students' attitudes and achievement. This study was designed to investigate the relationship of student attitudes toward the classroom environment and peer influence to attitudes toward science and achievement in science.

The tenth grades from four senior high schools of a school system in North Carolina were used for this study. There were 1500 students enrolled in 70 biology classes. Attitude and achievement measures of the students were collected at the beginning, middle, and end of the 1980-81 school year. The data indicate that there was a significant relationship between student attitudes and classroom climate and attitudes toward science at the middle of the year.

Session A-2

RESEARCH WORKSHOP

ASSESSING IMPLEMENTATION USING INNOVATION CONFIGURATION

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Science educators observe classroom-to-classroom variations in the use of innovations in science. Efforts are sometimes made by developers and others to reduce these variations. Skills in assessing the nature and extent of these variations could be helpful in determining their effects on student outcomes, monitoring and managing implementations of innovations, and in the design of innovations which have a better "fit" to the schools and teachers who use them.

The Concerns Based Adoption Model includes several strategies for studying implementation. One of these, Innovation Configuration, is a method of assessing classroom-to-classroom variations in use of innovations. This concept has been used by other researchers in their study of curriculum programs, mainstreaming, and microcomputers. This seminar will provide participants with skills necessary to develop their own instruments for assessing Innovation Configuration.

Session A-3

THE CONSTRUCTION OF A GROUP ASSESSMENT OF LOGICAL THINKING (GALT)

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The assessment of developmental reasoning is becoming a necessary part of teaching. The results can be used to modify science teaching strategies and help teachers better understand students' intellectual development.

Clinical interviews are often used to assess students' cognitive development. However, they are time consuming and require trained interviewers. To avoid these problems, many classroom tests of cognitive development have been developed. However, none measures more than five modes of reasoning and most are influenced by students' reading and writing abilities.

In light of these limitations, the investigators developed the Group Assessment of Logical Thinking (GALT) that (1) validly measures six logical operations, and (2) can be reliably administered in one class period.

Items were constructed which presented a problem. The student was to select the best answer and write his/her justification for that answer. The Fog Index was used to adjust sentences to produce a written test at or above the sixth grade level. Each of the twenty-one items included pictorial representations of real objects.

During development GALT was administered to students whose written justifications for each item were used to construct multiple choice justifications. In final form GALT was administered to 450 subjects in grades 6 through college. Conventional clinical interviews were conducted with some students as a means of investigating the validity of GALT.

Coefficient alpha for GALT was .89. The internal consistency of each subtest ranged from .13 to .85. Item difficulties averaged .55. Item discrimination indices averaged .44. The mean intercorrelation coefficients for subtests averaged .49. These results show that GALT has a high reliability and adequately measures six logical operations.

Session A-3

THE EFFECT OF METHOD AND FORMAT ON THE RESPONSES OF SUBJECTS TO A PIAGETIAN REASONING PROBLEM

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Researchers interested in studying the effects of subjects' reasoning levels, as defined by Piaget (e.g., Inhelder and Piaget, 1958), on science achievement or other dependent variables face two measurement problems. First, the traditional clinical method is time consuming and impractical for large numbers of subjects. Second, alternative methods of assessment, although reliable and valid, may overestimate or underestimate subjects' reasoning levels. The objective of this investigation was to determine the effects of various methods and formats of administering a Piagetian task on subjects' performance.

The task chosen for this investigation was the Mr. Short - Mr. Tall problem (Karplus & Lavatelli, 1969; Karplus et al., 1977). The task was presented by four methods: 1) individual clinical interview; 2) group presentation of task followed by paper-and pencil problem with illustration; 3) group administration of paper-and-pencil instrument with illustration; and 4) group administration of paper-and-pencil instrument without illustration. Each method included four formats: 1) completion answer with essay justification; 2) completion answer with multiple-choice justification; 3) multiple-choice answer with essay justification; and 4) multiple-choice answer with multiple-choice justification.

Three hundred and seventy-six students who were enrolled in a freshman level biological science class participated in the study. The research design is a 4 x 4 factorial design with method and format of assessment as the main effects. The participants were in 16 distinct laboratory or discussion sections, and each section was randomly assigned to a cell in the research design.

Regression analysis with the individual as the unit of analysis showed that neither method nor format of assessment accounted for a significant amount of variance in student performance. The overall interaction remained non-significant. Regression analysis with sections as the unit of analysis revealed similar findings. The inter-rater agreement in the scoring of the reasoning task was 98.4%. The principal conclusion is that neither method nor format of task administration influenced the performance of subjects, and this lack of influence is similar for various combinations of method and format. Discussion focused on the importance of this non-significant finding for using alternative methods of Piagetian assessment. Implications for teachers are also discussed.

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Session A-3

LOGICAL ABILITY IN REASONING WITH MATERIAL OF FAMILIAR CONTENT

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A study was conducted with 48 subjects (freshman and sophomores), all of whom were non-science majors enrolled in a Biology course in a junior college. Two tests, both in the syllogistic form, were administered to each subject. Each test contained two tasks of 8 questions each which could be correctly answered in one of three ways:

YES NO Can't Tell Because Two Possibilities Exist

One test (SS) contained material concerned only with shape (circle or square) and size (large or small). The other test was concerned with familiar material (FM) currently under discussion in the Biology course. The two tasks within each test were a material implication and an inclusive disjunction. The choice of tasks was based on prior investigations in which these appeared to be the most difficult to master.

It was of interest to observe whether familiar material might be treated differently from material of a decidedly less relevant nature. It must be noted that while the FM tasks were oriented toward a current Biology theme, success did not require information peculiar to a Biology course. In addition, while the material had familiar content (i.e. human pregnancy and delivery), it was outside the experience of the average student and therefore abstract (non-concrete) in nature. While it might be argued that shapes and sizes are familiar, it is highly unlikely that one is required to make an everyday decision based on these characteristics.

A statistical analysis of the means of the two tests showed that the subjects were much more successful with the FM tasks (significant at the .01 level). The correlation was high between similar tasks (0.55 for the disjunction and 0.73 for the implication task).

These results raised another question i.e., what particular logical skills are enhanced by familiar content? This will be the subject of another study.

Session A-3

PROPORTIONAL REASONING AND THE GENERAL LINGUISTIC ABILITIES OF HYPOTHETICO-DEDUCTIVE REASONING

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The hypothesis is advanced that a necessary, though not sufficient, condition for the acquisition of proportional reasoning during adolescence is the prior internalization of key linguistic elements of argumentation, essentially those used in hypothetico-deductive reasoning. This hypothesized internalization, which does not occur in all individuals, results in some who have acquired the ability to reflect upon the correctness of self-generated answers in a hypothetico-deductive manner, and others who have not. As an initial test of the hypothesis, 46 Ss (mean age = 21.03 years) were classified into additive, transitional, or proportional reasoning categories based upon responses to a proportions task. Group differences were found in which proportional Ss performed better than transitional Ss who in turn performed better than additive Ss on a number of items testing Ss' abilities to identify, generate, and use the linguistic elements of argumentation. Further it was found that some Ss who were successful on the linguistic items failed the proportions task but no Ss who were successful on the proportions task failed the linguistic items. This result supports the hypothesis that the internalization of linguistic elements of argumentation is a preprequisite for proportional reasoning and by inference other advanced reasoning schemata as well. Implications for science instruction are drawn.

Session A-4

THE USE OF PICTURES AS STIMULATORS FOR HIGH SCHOOL BIOLOGY STUDENTS' QUESTIONS FLUENCY, COGNITIVE LEVELS AND CONTENT INTEREST

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The goals of this study were: 1) to use pictures representing six levels of biological organization, (LBO), (cell, tissue, organ, organism, population, and community), in an imposed strategy as visual stimulators for high school students' questions. Then, those questions were analyzed for fluency, cognitive levels, and Biology content interests (BCI).

The sample included 588 high school students from 9th, 10th, 11th grades.

The instruments used were: 1) Thirty pictures representing the six LBO which were content validated (75% agreement). 2) A special key for analyzing students' questions was developed, and obtained a reliability of .78.

Results. After a pilot study, results obtained with the final sample were analyzed by three way analysis of variance (SPSS), using three independent variables, grade, gender, and LBO. A fourth variable, achievements in Biology, was added later. The effect of grade, gender, and LBO was found to be significantly related to fluency, cognitive levels, and BCI. Achievements in Biology yielded significant differences on fluency, low cognitive levels, and biological concepts. No interactions were found among LBC, grade, and gender. Most students' questions were realted to organism, population, and community. Results regarding cognitive levels show that most of the questions were asked in the low levels. Interactions were found between questions on cell, tissue, and community, and high cognitive levels on one hand, and organisms, and population with low cognitive levels on the other hand.

On biological content, most of the questions were related to structure and function, on the concept level only. Differences among the questions asked by 9th, 10th, and 11th grades, were found to be related to concepts, principles, structure, and function. Girls asked more questions related to organs and organisms than boys. No differences were found between low and high level achievers in fluency and cognitive levels.

The results are encouraging regarding the use of pictures as stimulators for students' learning motivation, as well as deepening the understanding of curricula planners in relation with students' interests and needs in science subjects.

Session A-4

THE EFFECTS OF CONTENT, COLOR, VISUALS, AND PAGE LAYOUT ON ELEMENTARY STUDENTS' ABILITY TO READ SCIENCE MATERIALS

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Present curriculum changes in elementary science indicate a need to reexamine a more traditional concern in science education: the readability of science textbooks. An area of reading research that has not previously been examined is the effect of color, visuals and page layout on readability of science materials. Using the Cloze method for measuring readability, the current study quantified the relationships between page format, grade level, sex and the science content areas of biological science, physical science and earth science.

The study was conducted with a random sample from urban, suburban and rural schools in British Columbia. The sample consisted of 272 subjects from grades 4, 5 and 6. Half completed a traditional Cloze test without colors or visuals and half completed a parallel Cloze test directly from a standard science text used in British Columbia schools.

Significant relationships were found between Cloze scores and both grade level and content. No significant relationships could be attributed to page format or sex. In the content area, physical science materials were most difficult to read followed by earth sciences and biological sciences. In terms of grade level, grade five materials were more difficult than grade six or grade four materials. In all cases, the science text material was at or near the frustration level of readability.

The implications for textbook writers and publishers are that science reading materials should be produced with more attention to readability and sequence of developmental reading skills. However, the use of color, visuals and various page layout formats do not adversely affect readability, although such formats do not promote readability. Further investigation is needed to determine the underlying causes of these differences in readability.

Session A-4

THE EFFECTS OF IMAGERY ON THE UNDERSTANDING OF TORQUE PROBLEMS FOR COLLEGE INTRODUCTORY PHYSICS STUDENTS

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A technique of examining a physical phenomenon, projecting an image of the event, and then diagramming that image was used to investigate the effects of imagery on the understanding of torque by college introductory physics students. Students were assigned to four groups. One group experienced an event, observed a slide, and then had diagrammed the slide data. A second group only saw the slides and diagram. A third group experienced the event yet saw only the diagram, and a fourth group saw only the diagram. No significant differences were noted as determined by analysis of variance. However, a theoretical model dealing with imagery suggests effectiveness of the technique when dealing with understanding various physical phenomena. Further study with the technique may prove to be fruitful.

Session A-4

THE EFFECTIVENESS OF COLOR VERSUS BLACK AND WHITE VISUALS USED WITH A COMPUTER PROGRAM SAFETY SIMULATION

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The purpose of this research study is to investigate the effectiveness of color line drawing visuals as compared to black and white line drawing visuals when used with a computer program simulation concerning safety in the science classroom laboratory. The content of the study is of value to science classroom laboratory teachers since safety in the laboratory is of paramount importance. Training teachers to correctly recognize and respond to hazards in the science classroom laboratory can be accomplished through the use of a computer program simulation. This study used a computer program simulation that had been demonstrated to be effective in teaching laboratory safety to preservice science classroom laboratory teachers. The subjects were assigned to groups according the Randomized Solomon Four-Group Design. The subjects used a colored line drawing visual and a black and white line drawing visual as a reference to the computer program simulation. Pretest and posttest measures of performance were made. No difference was found on the posttest measure between the subjects using the color line drawing visual and the black and white line drawing visual. It is suggested that there is no advantage to using color visuals with this computer program simulation.

Session A-5

A STUDY OF THE VALIDITY OF ATTITUDE MEASURES USED IN AN INTENSIVE TIME-SERIES STUDY

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A number of studies have been conducted over the past several years on the intensive time-series design. To date these studies have focused on establishment of the validity of measures of achievement in certain science concepts. The most recent such study by Farnsworth and Mayer (1982) concluded that the design and data gathering procedures did indeed produce valid achievement data. Each of these studies also included the collection of data on student attitudes. Until the Farnsworth and Mayer study, however, little information was available indicating the validity of the attitude data gathering techniques. An attempt was made in that study to gather attitude data that might indeed provide clues as to the validity of the technique. This paper reports on the analysis and interpretation of that data.

Five concepts each with six or seven adjective pairs, formed a pool of semantic differential items. Double item instruments were prepared from this pool and administered in a multiple group single intervention time-series design for 56 consecutive school days. Two groups of students, one with formal cognitive tendencies and one with concrete cognitive tendencies, were administered the instruments.

It was found that the intervention, a unit on plate tectonics, caused a positive shift in level of the series data. Also there was a clear difference in attitudes on four of the five concepts between the formal tendency students and the concrete tendency students. These results were consistent with those reported in the literature using traditional research designs. This and other evidence leads to the conclusion that the data gathering techniques used in this particular intensive time-series study appear to have yielded valid data on student attitudes. A study must now be designed to approach this question directly.

Session A-5

SEGMENTED STRAIGHT LINE REGRESSION ANALYSIS TO IDENTIFY MOMENTUM EFFECT FOR THE INTENSIVE TIME-SERIES DESIGN

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Several studies of the validity of the intensive time-series design have revealed a post-intervention increase in the level of achievement data. This so called "momentum effect" has not been demonstrated through the application of an appropriate analysis technique. The purpose of this study was to identify and apply a technique that would adequately represent and describe such an effect, if indeed it does occur.

Subsequent to trials of several different techniques, a segmented straight line regression analysis was chosen and used on three different data sets. Each of the three data sets revealed similar patterns of inflection points with similar durations for those data from students with formal cognitive tendencies. These results seem to indicate that this method will indeed be useful in representing and identifying the presence and duration of the momentum effect in time series data on achievement.

Session A-5

ADDING RESULTS TO A META-ANALYSIS: THEORY AND EXAMPLE

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Meta-analysis has been used as a reseach method to describe bodies of research data. It promotes hypothesis formation and the development of science education laws. A function overlooked, however, is the role it plays in updating research. Methods to integrate new research with meta-analysis results need explication.

A procedure is presented using Bayesian analysis. Research in science education attitude correlation with achievement has been published after a recent meta-analysis of the topic. The results show how new findings complement the previous meta-analysis and extend its conclusions.

Session C-1

A CRITICAL REVIEW OF RESEARCH RELATED TO LEARNING FROM SCIENCE TEXTBOOKS

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Learning from science textbooks occurs at all levels of science teaching and in nearly all school settings. There is, however, no research literature which specifically addresses the problems, practice, or outcomes of learning from science textbooks. Traditional curriculum evaluation studies in science education have considered textbooks merely as one element of an "instructional treatment," and often have failed to elaborate on content differences between treatments. Information-processing models of learning clearly suggest the importance of content in producing differential learning outcomes. Examples of recent research from the area of discourse comprehension (reading) illustrate feasible research methods and significant finding relevant to learning from science textual materials. This paper examines the failure of traditional science education research to address adequately the textbook as a learning variable; and, drawing on research concerned with discourse comprehension, suggests a paradigm within which content of textual instructional materials can be analyzed and meaningfully evaluated.

Session C-1

USING ADJUNCT QUESTIONS TO CHANGE PHYSICS STUDENTS' PERCEPTION OF A READING ASSIGNMENT INVOLVING COMPUTER-ANIMATED GRAPHICS

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The selective attention model is often used to explain the effects of adjunct questions on learning from a text. The model predicts that students who cannot comfortably assimiliate assigned reading material will selectively attend to the portion of the material necessary to complete the perceived task. Apparently, questions can alter the nature of students' perception of a reading assignment, thus persuading them to attend to and process teacher-determined categories of information contained within the assignment.

Adjunct questions, inserted after the segments of a science-lesson presentation using computer-animated graphics, were used to focus students' attention on questioned categories of information rather than on nonquestioned categories. The high-school lesson described the energy exchanges between incident particles and atoms.

Twelfth-grade physics students (N = 50) in a "naturalistic" setting were randomly assigned to two different question-treatment groups and a reading-only group. Subsequently, a low-level application posttest and a high-level application posttest were administered. The adjunct questions, posttest items and computer-displayed information were operationally defined and related to each other in accordance with the recommendations prescribed by Thomas Andre and Richard Anderson. As predicted, significant (p   .05) univariate interactions were detected for each posttest and a significant multivariate interaction (based on a regression approach) was detected after combining the posttest scores.

These findings extended previous works reported in this area to include: 1) learning under more typical classroom conditions; 2) using computer-animated graphics; 3) utilizing a design praised by researchers in the field; and 4) evaluating the processing of science information at two distinct levels of comprehension.

QUESTIONS IN TEXTUAL NARRATIVE: DO THEY MAKE ANY DIFFERENCE?

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The purpose of this research was to determine the relative effects of placement of questions when these questions were interspersed through the reading passage of textual materials for students in university introductory biology.

The sample consisted of all 425 students enrolled in a one-semester general biology course during the spring semester 1982 at a large midwestern university.

The sample was randomly sorted into seven treatment groups of approximately equal size. Early in the semester 61 students read a 2,354-word passage on bacterial adaptations taken from a popular university general biology textbook. A second group of 63 students read the same passage except that eleven questions were inserted, one at the beginning of each paragraph. These questions were of the descriptive of conceptual type such as "How do bacteria differ in body plan and why?", "How do bacteria survive hard times?", and "What factors influence bacterial growth and reproduction?" The questions were in each case directly related to the paragraph's concepts. A third group of 66 students read the same passage except that the questions were underlined. A fourth group of 64 students read the same passage except that the questions were presented in uppercase. A fifth group of 56 students read the passage with the questions set above the paragraph as a separate line. A sixth group of 54 students read the passage with the questions underlined and set above. A final group of students read the passage with the questions set above and in uppercase.

The criterion variable was a 20-item multiple-choice exam with five possible answers per question. The test was given once to all students immediately after they read the passage, yielding a Kuder-Richardson reliability value of .725. The same students took the same exam again exactly four weeks later yielding in a KR-20 value of .781.

Presentation strategy groups were contrasted against the reading without questions group. Four of the six groups reading with questions at the beginning of the paragraph scored significantly higher than the groups which read without questions on the test given immediately after the reading. There were no significant differences between any of the group scores for the test given four weeks after reading.

If it can be assumed that testing immediately after reading represents short-term retention, then it can be inferred that questions in textual narrative appear in most cases to increase short-term retention.

A tentative inference based on the data is that questions do help retain textual concepts, but only for very short time periods. The issue of questions in text as a learning strategy remains open and it is believed that further research on questioning strategies as reading aids is certainly warranted, especially in view of the existing emphasis upon learning by textual reading in our schools and universities.

Session C-2

DEVELOPMENT AND EVALUATION OF LESSON PLANS FOR COMPUTER SIMULATIONS

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Microcomputers are becoming common in schools and a variety of comupter programs is available in the science area. Little computer activity in classrooms results, however, because computers are in short supply and integration of the computer programs with the curriculum is difficult. The purpose of this project was to develop and evaluate lesson plans for using computer simulations in a group setting where a teacher used one computer with a class of students. The lesson plans included objectives, activities, strategies, and evaluation items. The lesson plans and computer simulations were tried out with inservice teachers in middle schools. The evaluation results showed cognitive achievement to be reasonably high and student response to the computer simulations to be highly positive. Some students would have preferred individual rather than group use of the computers. Inservice teachers rated the simulations and the lesson plans very favorably.

The results showed that limited computer facilities could be used effectively to achieve objectives in the science curriculum with accompanying positive reactions by students and teachers.

Session C-2

THE IMPACT OF MICROCOMPUTER BASED INSTRUCTION ON STUDENT ACHIEVEMENT

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The microcomputer is becoming an increasingly common fixture in classrooms. Both commercially and locally produced educational software is available for a variety of subjects with learning tasks ranging from simple repetitive drills to complex simulations.

The effectiveness of microcomputer based instruction is a matter of interest to educators and others. This paper provides an analysis of student achievement outcomes (both cognitive and affective) attributable to microcomputer based instruction. Classroom research studies on the topic were examined to determine the collective evidence on the impact of microcomputer based learning. The magnitude of effects are examined using the technique of meta-analysis for those reports that provide adequate data. Comparisons of instructional effects for microcomputers and large main frame computers are made. Gaps in the research literature are identified. The report on microcomputer impact has important implications for educational microcomputer users and researchers.

Session C-2

THE EFFECTS OF COMPUTER MANAGED DIAGNOSTIC TESTING ON SCIENCE ACHIEVEMENT FOR STUDENTS OF VARYING LEVELS OF MOTIVATION AND ABILITY

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The study was conducted to: (1) measure the effects of computer managed diagnostic testing on the immediate and subsequent achievement of high school biology students; (2) assess the effects of motivation and ability on this achievement; and, (3) determine if effects of the diagnostic testing were consistent across these student characteristics.

An experimental design was employed to measure these effects in three units of study of a BSCS biology course. The data were analyzed with statistical adjustment being made for any difference in achievement prior to treatment.

The results indicated that computer managed diagnostic testing was an effective and efficient means of increasing immediate science achievement and that the effect was consistent across levels of motivation and ability. In regard to subsequent achievement the earlier diagnostic testing experience appears to have negatively influenced achievement, possibly because of a dependence on the diagnostic feedback. As for the student characteristics, ability had a positive relationship with achievement while motivation level had none.

Session C-3

NATIONAL MONITORING OF SCHOOL SCIENCE IN GREAT BRITAIN: A REVIEW OF ISSUES

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Large scale monitoring of pupils' performance produces results which teachers, parents, politicians wish to use. The paper discusses the problems of interpretation of results, with reference to the national monitoring of school science in the United Kingdom.

The first main section considers the possible significance of the differences between score levels on different dimensions of pupil performance obtained in 1980 surveys. Interpretation of the numbers demands understanding of the processes of validation, selection by pre-testing, marking and analysis. It is argued that such scrutiny will show that significant differences, of importance to science educators, have been revealed.

The second main section discusses results obtained by asking adults, individuals and groups, to answer selected test items, to predict pupil scores, and to specify minimum scores for satisfactory performance. The samples were drawn from both inside and outside teaching. The main result is the wide variations within groups, and disparities between many different aspects of their responses. It is concluded that if actual test items are the starting point then no consistent pattern of expectation emerges. The publication and dissemination of results may alter this, perhaps by establishing test norms as criteria for the future.

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AN OVERVIEW OF THE FRAMEWORK FOR NATIONAL MONITORING IN SCIENCE

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In 1974 the Department of Education and Science in England initiated a national assessment programme, and national surveys are now being carried out in four areas: mathematics, science, language and modern languages. The test development and the conduct of the tests is being undertaken by teams at Chelsea College London and the Centre for Studies in Science Education, Leeds University.

This paper describes in outline the science monitoring programme, including the assessment framework, description of the types of tests used, the method of sampling and the main emphases in reporting the results.

Session C-3

PERFORMANCE LEVELS: DESCRIPTION AND DATA

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The data from the Assessment of Performance in Science surveys (commissioned by the Department of Education and Science in England and conducted by teams at Chelsea College, London and Leeds University) are used to address different kinds of issues including

- producing descriptions of levels of performance of pupils ages 11, 13 and 15 on a range of types of activity
- investigating differences in levels of performance between different groups of pupils.

Two approaches to analysing and reporting the results are described in the paper.

STANDARDS OF PERFORMANCE - EXPECTATIONS AND REALITY

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Large scale monitoring of pupils' performance produces results which teachers, parents, politicians wish to use. The paper discusses the problems of interpretation of results, with reference to the national monitoring of school science in the United Kingdom.

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Session C-4

TEACHER-STUDENT COGNITIVE STYLE AND ACHIEVEMENT IN BIOLOGY

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The study investigated the effects of teacher-student cognitive style matches and mismatches on student achievement in biology. Tenth-grade biology students and their teachers were classified as field-independent (FI) or field-dependent (FD). Students were instructed on a unit in a biology textbook. Student achievement was assessed by pre-and post-treatment scores on an achievement test. Field-independent students achieved significantly higher scores than did FD students with both FI and FD teachers, but FD students achieved significantly higher scores with FI rather than FD teachers.

Session C-4

A META ANALYSIS OF STUDIES ON COGNITIVE PREFERENCES IN SCIENCE LEARNING

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Fifty-four studies of cognitive preferences (CP) in science were meta-analyzed using four types of data, namely: standard scores, effect sizes, correlations and factor analysis. The following independent variables were included: type of respondent, grade level, ability, achievement, gender, type of school, kind of curriculum, curriculum profile, desired career goals, teacher orientation, country, type of test responses, type of measuring instrument, subject matter area. Frequency distributions are reported for each of the above mentioned variables. Some of the main findings are: In general CP tests exhibit reliability coefficients acceptable for group comparisons. The four CP modes tend to form two dimensions: Q-R (designated "curiosity") and P-A (designated "utility"). Particular CP tests have particular biases which depend partially on their subject matter. Students in different countries differ in their CP patterns. Students of inquiry oriented curricula tend to have a higher preference for P and Q and a lower preference for R than do students of traditional curricula. Regardless of the nature of the curriculum, high achievers tend to have a higher preference for P and Q and a lower preference for R. Effect sizes which can serve as base lines for further research are presented. The construct validity of CP is strongly supported. Implications for science teaching are discussed.

Session C-4

THE RELATIONSHIP OF ATTITUDE, COGNITIVE ABILITY, AND PERSONALITY TO SCIENCE ACHIEVEMENT IN THE JUNIOR HIGH

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One hundred male and female junior high school students were given the Scientific Attitude Inventory, Spatial Rotations, and the Myers-Briggs Type Indicator. Science and mathematics grades were used as measures of these abilities.

Attitudes and mathematical ability seem to affect science grades more than do personality factors. There were few sex differences. However, girls could be distinguished from boys in that they were more extroverted than boys, less likely to have positive attitudes towards science, and more likely to have higher science grades.

Analysis by grade reflects the same phenomena. Students receiving a grade of A are more likely to be female, extroverted, and have a negative attitude toward science.

It appears that although girls in junior high are not hindered by less mathematics or spatial ability than boys and outperform them in science, they do not like the subject and lack an important personality characteristic associated with science. If these girls do not take more science in high school this situation will be based on attitude and inclination, not aptitude.

Session C-5

DIFFERENCES IN ATTITUDES BETWEEN ACADEMIC CONTINUING AND ACADEMIC TERMINAL SECONDARY SCIENCE STUDENTS

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The purpose of this study was to compare attitudinal data on students who had dropped college preparatory science (academic terminal) in high school with those who continued to enroll (academic continuing) in college preparatory science courses.

Eight attitudes that have been hypothesized to be related to learning, cognitive performance, and enrollment in science were assessed. These were Science Usefulness, Confidence in Learning Science, Science as a Male Domain, Effectance Motivation in Science, Success in Science, Teacher Support, Parental Support, and Peer Support.

The attitude scales were administered to 108 academic continuing students and 55 academic terminal students in a Central Pennsylvania high school. The independent variables were two levels of gender (male, female), three levels of grade (tenth, eleventh, twelfth), and two levels of science program (academic terminal, academic continuing). The dependent variables were the previously mentioned eight attitude scales.

The data were analyzed using Multivariate Analysis of Variance and Duncan's Multiple Comparison Test. Significant differences (P .01) were found for the main effects of gender and science program. There were no significant differences for the main effect of grade or for any two- or three-way interaction.

Discussion of the results, implications, and suggested future research are included.

Session C-5

A COMPARISON BETWEEN HYPOTHESIS TESTING STRATEGY AND ACADEMIC ACHIEVEMENT OF FRESHMEN BIOLOGY STUDENTS

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The purpose of this study was to evaluate the hypothesis testing strategy of freshmen biology students and comparing it with final grades.

Forty nine (49) subjects enrolled in a first year experimental biology class, funded in part by an NSF grant, at a major Eastern University were administered the Turtle Task. This test developed at Rutgers University is a clinically administered hypothesis testing task adapted from Wason and Johnson-Laird four card task (1972).

Results of the test indicated that, of the 49 students enrolled in this course 29 used a verification strategy in testing a hypothesis and 20 used a falsification strategy. Overall a greater percentage of students categorized in the falsification group achieved higher grades than did those categorized in the verification group.

Further study is needed to determine whether students who used the falsification strategy in testing the hypothesis learned the strategy in this course or elsewhere.

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Session C-5

PREDICTING ACHIEVEMENT IN COMMUNITY COLLEGE SCIENCE STUDENTS

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This study was designed to formulate a predictive equation to identify community college biology students (N = 420) who most probably would not succeed in a science course. A College Biology Student Survey (developed for the study), the Nelson-Denny Reading Test (Form F), the College Guidance Placement (CGP) Arithmetic Test, and An Inventory of Piaget's Developmental Tasks (IPDT) were used to obtain the students' background characteristics, reading/math ability and cognitive development level.

Data collected from students in 22 biology classes indicated: more females (82%) than males (22%); a mean age of 26; racially balanced classes (49% white, 51% non-white); that 71% were single or formerly married; that 9% were at the formal level of cognitive development; a mean score of 15/25 on the math test (measuring 6th grade math ability); an average 12th grade reading level, and an average course grade of 2.7 (C+).

When data were analyzed using multiple regression, background characteristics and reading/math ability accounted for 42% of the variance in achievement. Cognitive development accounted for 12.8% of the variance in achievement. With cognitive development as a mediating variable, background characteristics and reading/math ability accounted for 22% of the variance in achievement. Recommendations were made on a predicted equation formulated from these results.

Session D-1

ATTITUDE-RELATED STUDIES IN SECONDARY SCHOOL SCIENCE

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COMPATIBILITY OF STUDENT CHARACTERISTICS AND INSTRUCTIONAL STRATEGY: AN INVESTIGATION OF THE MATCHING HYPOTHESIS

This study was an investigation of the matching hypothesis with students (N = 574) enrolled in ninth grade physical science. Instruction was designed to meet student learning needs on three variables: cognitive style, locus of control, and need level. Attitudes and achievement served to measure the effectiveness of matching.

An experimental group was formed which used an instructional strategy designed specifically for the study. A control group studied the same physical science topics as the experimental group but under unrestricted instructional requirements. Student outcomes of the two groups were compared. The experimental group students were then classified into one of eight groups according to their combinations of characteristics, with each group varying in its degree of compatibility with the experimental instructional strategy. Differences in attitude and achievement outcomes among the eight groups were investigated.

Curvilinear relations of student outcomes as functions of degree of compatibility with the instructional strategy were obtained from covariance analyses, suggesting support for activation-arousal theory. The amount of enhancement of attitudes and the nature of the relationship between attitude and degree of compatibility with the instructional strategy were found to depend upon the attitudinal object.

THE EFFECTS ON PUPILS' ACHIEVEMENT AND ATTITUDE OF TRAINING SECONDARY SCIENCE STUDENT TEACHERS TO MATCH TEACHING STRATEGIES TO PUPILS' LEARNING STYLES

This study sought to train secondary science student teachers to teach using strategies compatible with the learning styles of pupils in their classes and to measure the effects of matching on pupils' achievement and attitude. Secondary science student teachers (N=16) and students enrolled in the classes they taught (N=32) participated in this study.

Learning style profiles were obtained from secondary science student teachers and students enrolled in the classes they taught; this information formed the basis of the training session. In addition, concerns information was collected from student teachers on three occasions: midway through student teaching, approximately two weeks later, and prior to completing student teaching. The attitudes of secondary science students toward their student teacher were measured midway through and at the end of student teaching. Information on students' academic performance was provided by student teachers and served as the measure of achievement.

Results indicated that once concern for self and concern for the task of student teaching decreased, student teachers demonstrated a concern for the impact of their teaching and used greater variety in their teaching strategies, a better match for students' learning styles. High impact concerns were found to be directly correlated with pupils' achievement. Moreover, the directness of the teaching strategies used by the student teacher was found to be correlated with pupils' achievement. Neither the concerns level nor the varied nature of the teaching strategies used by the secondary science student teacher were found to be related to the attitudes of pupils toward the student teacher.

A META-ANALYSIS OF INSTRUCTIONAL CHARACTERISTICS INFLUENCING ATTITUDES TOWARD SECONDARY SCHOOL SCIENCE

Literature relevant to attitudes in secondary science education was identified from the period 1960 to 1981. This literature was then examined and categorized based upon its treatment of instructional and institutional independent variables, and their contribution to influencing attitudes among secondary school students. A meta-analysis was then conducted on the research findings dealing with the subcategories of teacher, student, and environment characteristics within the instructional setting. Because of the lack of alternative school studies which employed the criterion variable of attitude toward science, the data retrieved from the literature examining the effects of the non-traditional school were not meta-analyzed.

The meta-analysis procedure identified both the direction and strength of various factors in influencing the formation and change of attitudes toward science among secondary school students. Variables related to teacher affective characteristics and students' perception of the climate of the learning environment, as well as the role of students in designing and administering their own instructional activities, were all demonstrated by the meta-analysis to be influential in modifying student attitude toward science favorably. Implications of the findings of the meta-analysis are discussed using both social learning theory and Katz' functional theory as a theoretical framework for describing attitude formation and change.

Session D-2

RESEARCH WORKSHOP

BUILDING PREDICTIVE MODELS WITH LOG-LINEAR ANALYSIS

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This seminar will prepare science educators to use log-linear analysis in building predictive models with cross-classificational data. The seminar will demonstrate the value of log-linear analysis in science education research, especially where policy-making is involved. Other segments of the workshop will focus on the conceptual/statistical basis, organizing data, writing the computer programs, interpreting output, and step-wise model building. Extensive handouts and references will be provided.

Session D-4

INFLUENCES OF A SECONDARY SCIENCE METHODS COURSE WITH A MICROTEACHING EXPERIENCE ON PRESERVICE TEACHER DEVELOPMENT

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Recent indepth classroom studies have elucidated characteristics of effective classroom managers, planners, decision makers, and good teachers and teaching. However, little has been done to describe if and how these described characteristics develop in preservice teachers.

In this study ten secondary preservice teachers were interviewed and given planning tasks to complete prior to and following their experience in a science methods course which included planning and teaching four inquiry science lessons to small groups of sixth grade students. Interview responses and lesson plans were analyzed to produce initial and final descriptions of how the preservice teachers (a) planned for instruction, (b) defined criteria of good instruction, (c) understood the nature of teaching, and (d) understood the nature of students.

These descriptions were then used to describe five different teaching styles found among the preservice teachers. The five teaching styles were characterized as:

1. Performer: views students as passive objects of instruction.
2. Text driven: follows the prescription of commerical curriculum materials without modification.
3. Activity driven: primarily concerned with how to do and what needs to be done to keep students engaged in manipulative activities with little regards for learning outcomes.
4. End results orientated: engages in post instructional assessment with tests or application problems.
5. Conceptual change orientation: preassesses student knowledge and uses more than one strategy to achieve objectives.

Initially seven preservice teachers were characterized as performers, one text driven, one activity driven and one end result orientated without two of the preservice teachers characterized demonstrating an awareness of more than one style of teaching. Following the course no teachers were still characterized as performers. One was text driven, one activity driven, four end results orientated, and four conceptual change orientated. All ten preservice teachers demonstrated some positive change in teaching style.

Session D-4

USING GRADES OBTAINED ON THE PHYSICS TEST OF THE UNIVERSTY ENTRANCE EXAMINATION AS ACHIEVEMENT INDICATORS FOR STUDENTS ENROLLED IN GENERAL PHYSICS IN BRAZIL

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The purpose of this study was to find out if the results obtained by students on the physics test of the University Entrance Examination could be used as indicators of achievement in a general physics course at the Federal University of Santa Maria, Rio Grande do Sul, Brazil. The two hundred and eighty-nine students who participated in the study passed the University Entrance Examination in 1979 and 1980, and enrolled in the major areas of physics and engineering (civil, electrical, mechanical and chemical). The general physics course was required to all of them.

Data were obtained from the Office of the Registrar, the Center of Data Processing, and the Physics Department. Analysis of variance, Pearsons's moment correlation and TuKey's test for multiple comparison were used to analyze the data.

Results showed a positive correlation between the performance on the University Entrance Examination and achievement in the general physics course only for students majoring in physics, civil engineering and mechanical engineering. Significant differences were found between the performance of males and females on the University Entrance Examination but not in the general physics course.

Session D-4

AN ASSESSMENT OF NEED AMONG SECONDARY LEVEL JORDANIAN SCIENCE TEACHERS

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The purpose of this study was to identify the most prevalent needs perceived by Jordanian secondary level science teachers. The Science Teacher Inventory of Need (STIN) was developed and used for that purpose. STIN content validity, reliability and construct validity were established. Most prevalent needs were defined as the top twenty needs designated by respondents based upon STIM item mean values. During January of 1982 the STIN was distributed to an accessible population consisting of 444 secondary level science teachers in four of the five districts of Jordan. Completed inventories were returned by a sample of 365 teachers (82.2%). Mean STIN item responses calculated for the entire sample and subgroups of it, e.g., field of science specialization, allowed identification of the most prevalent needs perceived by the sample of science teachers and subgroups of them. Conclusions are drawn as to the inservice needs of Jordanian science teachers. The implications those conclusions have for preservice and inservice science teacher education in Jordan are discussed.

Session D-5

TWO YEAR STUDY RELATING ADOLESCENTS' SELF CONCEPT AND GENDER ROLE PERCEPTIONS TO ACHIEVEMENT AND ATTITUDES TOWARD SCIENCE

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To assess the developmental relationship of perceptions of self concept and gender role identification with adolescents' attitudes and achievement in science, a two-year longitudinal study was conducted. A battery of instruments assessing 16 dimensions of self concept/gender role identifications were employed to predict students' achievement and attitudes toward science. Specific behaviors studied included self concept in school and in science, and mathematics, attitudes toward appropriate gender roles in science activities and careers and self perceptions of masculine and feminine traits.
One hundred and fifty-five adolescents, enrolled respectively in the seventh and eight grades, participated in the study. Through Fisher z transformations of correlation coefficients, differences in relationships between these two sets of variables were studied for males and females during the two years. Results indicated that students' self concepts/gender role perceptions were related to both achievement and attitudes toward science, but more related to attitudes than achievement. These relationships became more pronounced for students in the eighth grade. These data infer a need for developing science programs for adolescents which do not reinforce the stereotype of science as a male domain, if more girls are to continue their studies in advanced science.

Session D-5

CHARACTERISTICS OF MALE AND FEMALE STUDENTS WHO EXPERIENCED HIGH VERSUS LOW SUCCESS IN THEIR FIRST COLLEGE SCIENCE COURSE

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This study compared men and women who experienced either high or low success in their first collegiate science course on SAT scores, satisfaction with their course performance, expectations for future success, attributions for success or failure, and a number of psychological variables. Subjects for the study were 133 freshmen at Colgate University. The results showed that on three variables-- persistence, lack of reckless or rash tendencies, and future orientation-- score differences were significant between high and low success women but not between high and low success men. The results imply that career goal orientation may be important in women's success in science and that women continue to struggle against a social norm which says that science is a masculine field.

Session D-5

DIFFERENTIAL EFFECTS OF TEACHING METHOD AND TIME AVAILABLE FOR STUDY ON MALE AND FEMALE STUDENTS IN A HIGH SCHOOL SCIENCE COURSE

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This study assessed differences in science achievement between males and females. Subjects for the study were 1,397 high school students enrolled in the first three month segment of a full year science course based on minicourses developed by the Individualized Science Instructional System (ISIS). The subjects were exposed to three levels of time restrictions for completing their work (HiT, MedT, LoT) and to two teaching methods (student directed (SD), and teacher directed (TD).) Ability was a covariate. The pattern of effects on achievement of varying the time available for study were the same for males and females under TD (MedT was most favorable with performance falling off under LoT and HiT). Males outperformed females at all levels. Under SD the effects were different. For males performance was lowest under MedT and improved under both HiT and LoT. It is suggested that variations in teaching methods and time available for study might be used to improve the performance in science courses of both males and females and/or to improve the relative performance of females.

Session E-1

UNDERSTANDING THE NATURE OF SCIENTIFIC KNOWLEDGE: INTERVIEWS WITH COLLEGE STUDENTS

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Some general results of a detailed descriptive investigation of students' positions toward controversial issues in theories of scientific knowledge are presented. The work is based on recent evidence from conceptual change research in science and mathematics education which suggests that an individual's beliefs about knowledge may play a role in what that individual chooses to learn and how. Thus, the goal of the research reported here was to identify beliefs people hold about the nature of scientific knowledge.

Items from a survey on the nature of scientific knowledge were used as a stimulus in individual interviews with 30 college biology students who had previously responded to the survey. Eighty percent of the sample were first year students. Items pertained to one of three issues in epistemology of science and each item reflected one of two theories of scientific knowledge: empiricist or constructivist.

Three themes emerge in students' comments about the nature of and growth of knowledge. 1) Knowledge is based on observed facts, it is discovered and it accumulates rather than changes over time. 2) Knowledge is discovered as in (1), but it changes with new evidence and better techniques. 3) Knowledge is constructed based on theories which guide and limit observations and objectivity. It evolves via changing theories.

On the nature of objectivity, the majority of students say that observations can be made with a mind clear of contaminating thoughts. A few students said, however, that training, background and knowledge will inevitably affect observations and are required for observations.

The results of this study can serve as foundation for study of interactions between epistemological positions and learning/achievement. However, the results are of immediate value to the classroom science teacher.

Session E-1

RECONSIDERING THE SCIENCE CURRICULUM: CLUES FROM THE STRUCTURE OF SCIENTIFIC THEORIES

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Recent criticism of precollege science education has focused on both the quality and quantity of instruction which occurs. Position statements and strategies for combating the crisis have been published by NSTA, AAAS, and NAS. It is time, however, to begin asking fundamental questions concerning the nature of the science curriculum as it presently exists. Specifically, to ask whether or not it can be effective in delivering the type of solutions being posited by NSTA, AAAS, and NAS.

The paper presents the position that science education has neglected to synthesize into precollege science curricula the important writings and insights of historians and philosophers of science. Since the 1960s science education and philosophy of science have both undergone great changes. Science educators began to focus on the pedagogy of learning science by investigating its processes. Philosophers, on the other hand, began to focus on the structure of scientific theories in their attempt to learn about the scientific enterprise. "It is only a slight exaggeration to claim that a philosophy of science is little more than an analysis of theories and their roles in the scientific enterprise." (Suppe, 1977, Introduction)

In arguing that the latter approach of the philosophers has merit for science education, the paper:

1) describes the dominant views about the structure of scientific theories developed during the twentieth century;
2) presents the argument that science curricula as described by research can be said to rest in the camp of the oldest, rejected, views; and
3) demonstrates, with an example, how contemporary models of the structure of scientific theories can be used to provide sound bases for a retooling of precollege science education programs and curricula.

It is time for science education to assess the value of models of the structure of scientific theories in developing science programs and curricula.

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Session E-1

DISTINGUISHING FEATURES OF GENETIC EPISTEMOLOGY: THE OBJECT OF STUDY AND THE METHODOLOGY

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This analysis abstracts criteria to distinguish science from non-science, distinguish physical science from social science, and further distinguish genetic epistemology from other social scientific approaches. Genetic epistemology distinguishes the operatory from the figurative aspects of a concept as an action system. The first is derived by physical or Aristotelean abstraction and the second by reflective abstraction. In addition, the scientist must understand assimilation as a fundamental concept in order to understand how action systems improve themselves by autoregulation to become concepts. Whereas the child understands a physical object which remains static, the scientist object of study, the child's cognition, involves a moving equilibrium. Physical objects don't develop; children's conceptions of objects do. From genetic epistemology Piaget's equilibration model provides a research model of this moving equilibrium system that is action in thought. Developmental theories can be evaluated to determine their ability to capture the notion of assimilation and so their point of development as scientific theory.

Session E-3

ENERGY KNOWLEDGE AND ATTITUDES AND LOCUS OF CONTROL OF SECONDARY TEACHERS:

STUDY II

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The purpose of the study was to measure the energy knowledge and attitudes and locus of control between the participants of a DOE faculty development workshop. The data were compared to another DOE workshop (Barrow, 1982).

The 100 item Energy Inventory (Glass, 1979) and Environmental Q-sort (Humphreys, 1975) were utilized to determine the energy attitudes for both groups. The Energy Inventory was also used to determine the energy knowledge. The James' Internal-External Locus of Control Scale (1957) was administered once to the participants.

Pre-test data were collected from 29 secondary teachers (17 science teachers, 8 social studies teachers, 2 industrial arts teachers and 2 home economics teachers) who participated in the DOE program. The Energy Inventory and Q-sort were administered on the first day of the program (July 1981). Posttest data were collected in October, 1981. Data were analyzed by SPSS (Nie, 1975). Like the 1980 workshop participants had an increase on the knowledge subscale and the use of energy items from the Energy Inventory. Also, biomass users scored significantly higher than did non-biomass users. In contrast to the 1980 workshop, the 1981 science teachers had a greater energy knowledge base than non-science teachers.

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Session E-3

EFFECTS OF A SUMMER INSTITUTE ON MIDDLE SCHOOL SCIENCE TEACHERS' ENERGY KNOWLEDGE AND ATTITUDE AND ENERGY EDUCATION IMPLEMENTATION

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The Summer Workshop for Energy Education Teachers in Texas (SWEET-TX) was designed to improve Texas Middle School Science Teachers' understanding of energy issues and concepts. Twenty-five participants attended the summer workshop from June 21 to July 9, 1982. The workshop consisted of 62 hours of direct instruction, 32 hours of field trip activities, and 14 hours of laboratory activities. The energy topics were presented by experts from science and engineering disciplines, Gulf Oil Corporation, as well as local representatives of citizen action groups. Topics for the course were covered using a variety of methods and approaches. Instruction was provided about DOE and other energy education materials.

An evaluation of the effects of the program indicates that SWEET-TX was successful at increasing the teachers' energy knowledge and positive attitude as indicated on the National Assessment of Educational Progress energy test for young adults. The usefulness of the workshop and overall reaction of the participants to the workshop were rated very high. The participants expect to enroll a mean of 147 students this year in energy related courses. One hundred percent of the participants plan to teach energy during the following year.

Session E-3

AN EVALUATION OF TWO DEPARTMENT OF ENERGY SPONSORED WORKSHOPS AND A COMPARISON BETWEEN PARTICIPANTS' ENERGY LITERACY AND THAT OF THE GENERAL PUBLIC

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The purpose of this study was to evaluate two Department of Energy sponsored teacher workshops using a test developed from released National Assessment items. A second purpose was to compare the teachers' degree of energy literacy with that of a national sample of adults.

During the years 1976 and 1977 the National Assessment of Educational Progress conducted a survey of young adults' achievement and attitudes in energy, health, reading and science. Because of its survey nature NAEP items were not constructed as scales or tests. For this study NAEP items were combined into valid and reliable tests and then used in two ways. First the energy tests were used to evaluate the effects of two DOE workshops on changes in teachers' knowledge and attitudes about energy. Second, the item responses of the 1976-77 survey of adults (N=1289) were reanalyzed using the same scales administered to the workshop teachers.

Preliminary results indicate that the workshops increased teachers' knowledge about energy and that in comparison to the general public, teachers' score significantly higher on the overall cognitive energy test.

Session E-4

A STUDY OF POLICY & PROGRAM FORMULATION & IMPLEMENTATION IN A SECONDARY SCHOOL SCIENCE DEPARTMENT

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An ethnographic study was conducted of the secondary school science department in a midwestern, suburban, middle/upper middle class school district of 1850 students. The purposes of the research were to observe, describe, and analyze:

(1) how policies and programs for secondary school science are formulated and implemented in the district;

(2) sources of information and means used by teachers and administrators to acquire new information about science and science teaching; and

(3) how teachers' values, belief systems, knowledge, attitudes and commitments affect their selection of content, methods of teaching, standards, and classroom interactions with students.

The report provides a detailed description of the operation of a suburban secondary school science department. Interactions among administrators, teachers, and students are analyzed as well as the factors which underlie policy and program decisions about the science curriculum. Data are also presented on strategies used by teachers to maintain currency in science content and pedagogy. An analysis of the discrepancy between potential and actual practice in science instruction is also provided which is based on sociological studies of workers and the workplace.

Session E-4

THE PLANNING AND TEACHING INTERMEDIATE SCIENCE STUDY: AN APPLICATION OF COGNITIVE SCIENCE TO CLASSROOM RESEARCH AND CURRICULUM DEVELOPMENT

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Recent research in the field of cognitive science has demonstrated that students' understanding of a wide variety of scientific concepts is influenced by the existence of preconceptions which are in conflict with accepted scientific theories. In this study, student preconceptions were used as a basis for analyzing classroom behavior of teachers and students and for developing modifications that increased the effectiveness of commercial science programs.

The study lasted for two years. During the first year case studies were conducted of 14 teachers teaching either (a) the Light unit from the Laidlaw Brothers' Exploring Science textbook, or (b) the Producers section from the SCIS Communities unit. Pretests revealed that most students had important preconceptions which conflicted with the scientific ideas presented in the program materials. For instance, most students believed that plants take in food from the soil, rather than making it through the process of photosynthesis. Although the teachers exhibited a variety of teaching styles, none was particularly successful in changing students' preconceptions.

During the second year of the study, modifications were developed for both of the target units and used by 10 teachers. The modified materials informed teachers about their students' preconceptions and suggested strategies for helping students to change. Classroom observational data showed important changes in the teachers' behavior, and student learning was significantly improved.

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Session E-4

CURRICULAR INNOVATION AND TEACHER ROLE CHANGE: AN EXPLORATORY STUDY

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Changes in teacher behavior are critical to provide science programs appropriate to the Eighties and beyond. Therefore, it is significant to address factors that influence a science teacher's willingness to initiate change.

The purpose of this qualitative study was to understand the factors which influenced the teacher's behaviors during the implementation of an innovation and to develop a theoretical model showing the relationships of these factors.

The vehicle for the study was Project Advance Biology (PAB), an audio-tutorial first year college course, which was implemented in five high schools by high school teachers during 1976-1977.

Participant observation and open ended interviews were used to gather data. Role theory and symbolic interaction were used as the framework for data analysis. A theoretical model grounded in the data was developed to account for the factors influencing the success of the innovation.

A quantitative study in 1980 by Dr. V. Lien verified the significance of the factors identified in this study.

Since 1977, this model has contributed to the success of varied innovations. For example, the implementation of:

°National marine education policy
°Eight teacher training courses, and
°PAB in twenty schools by 1982.

Session E-5

THE EFFECTS OF COGNITIVE DEVELOPMENT, AGE AND INQUIRY STRATEGY ON ELEMENTARY STUDENTS' SCIENCE ACHIEVEMENT

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Age and cognitive development of learners were assessed for 151 elementary school students in grades one, three and five. Approximately one-half the sample received instruction in each of two science units. One unit was designed around the topic of "Seeds," utilizing a structured inductive inquiry teaching/learning strategy. The second unit considered "Magnets," using a semi-deductive inquiry teaching/learning strategy.

Achievement data from two content specific tests were analyzed. The results indicated that age became a non-significant factor after grade three, and cognitive development was a critical factor for both inquiry strategies. Generally non-conservers and non-multiplicative classifiers scored significantly lower than students who successfully performed the conservation and multiplicative classification tasks.

The study appears to suggest that by age eight or nine years students possess the logical structures required by structured inductive and semi-deductive teaching/learning strategies.

Session E-5

THE EFFECT OF SCIENCE TEACHING ON THE FOURTH GRADE KOREAN CHILD'S CONCEPT OF PIAGETIAN PHYSICAL CAUSALITY

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The purpose of this study was to determine if selected science experiences affect the fourth grade Korean child's concept of Piagetian physical causality and to determine if cross cultural differences exist between children of Korea, the United States, and Trinidad and Tobago.

The study involved 208 fourth grade Korean children selected randomly from the Attached Primary School, Inchon Teachers College, Inchon, Korea, of which 104 children were assigned to an experimental group and 104 children to a control group. Four classroom teachers and eleven college students were trained before the treatment period so that the classroom teachers would be familiar with teaching content and materials and college students would be acquainted with the clinical interview technique.

The instruments used for the pretest and posttest in this study were the Concept Assessment Kit-Conservation (Form A), The I. Q. Test (Form A), and the Clinical Interview I and II for the assessment of the concepts of living and floating. The statistical methods used for the data analyses were Chi-Square, Kruskal-Wallis One-Way Analysis of Variance, Analysis of Variance, Spearman Rank Order Correlation Coefficient and the t-test.

The experimental subjects were taught the concept of floating and the concept of living for 150 minutes respectively while the control subjects were taught language arts as a placebo for 300 minutes. The independent variables were science experiences, sex of the child, verbal ability, mathematical ability, and stage of development. The dependent variables were the child's concept of physical causality, particularly the causal relations of animism and dynamism and the change in developmental level.

Analysis of the resulting data revealed several significant findings in the areas of science teaching, sex comparison, verbal and mathematical ability, and the developmental stages. Significant differences were found between the experimental and control groups. The experimental group was in general superior to the control group. No significant difference was found between the experimental males and females, or between the control males and females for both causal relations of animism and dynamism. Both the experimental males and females showed significantly higher scores than did the control males and females for the causal relation of dynamism, but did not show any significant difference in the scores for the causal relation of animism since all subjects learned about living and non-living things when they were in the first grade. As a consequence many of them were classified as either in transitional or true causality before the treatment period. The results indicated significant correlations between the child's verbal and mathematical ability and his/her ability to understand the causal relations of animism and dynamism. No significant difference was found between children who showed a change in developmental level and those who did not show a change.

From the results of this study, it was concluded that the causal relations of animism and dynamism could be taught to the fourth grade Korean children. The fourth grade Korean child's ability to understand the causal relations of animism and dynamism was in general similar to children of the United States and Trinidad and Tobago.

Session E-5

AN EXPERIMENTAL STUDY INTO THE EFFECT OF SCIENCE TEACHING ON THE TRINIDADIAN FIFTH GRADE CHILD'S CONCEPT OF PIAGETIAN PHYSICAL CAUSALITY

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This study investigated the effect of science experiences provided by the classroom teacher on the fifth-grade Trinidadian child's concept of Piagetian physical causality. The sample comprised 835 children from 37 schools.

The dependent variables were the child's concept of physical causality, in particular the causal relations of animism and dynamism and the change in cognitive developmental level. The independent variables were group, gender, verbal ability and developmental stage.

The procedure involved a rigorous teacher-training and monitoring system and the creation of an experimental group, which received science instruction and a control group, which received language arts instruction. These tests used were the Concept Assessment Kit - Conservation Forms A & B, the Metropolitan Achievement Test, Form C, and two clinical interviews which assessed the child's concept of living and floating.

The results indicated that the experimental group scored significantly higher than did the control group. In the experimental group girls scored significantly higher than boys; no significant difference was found between boys and girls for the concept of floating. No difference was found between boys and girls of the control group for both concepts.

Scores on the verbal ability and clinical interviews were highly correlated. The experimental preoperational, transitional and concrete stage children scored significantly higher than the children in the same developmental stage in the control group.

It concluded that participation in selected science experiences tended to accelerate or enhance the understanding of the concepts of living and floating. The causal relationships of animism and dynamism could be taught to fifth-grade Trinidadian children.

Session G-1

PARENT AND CHILDREN LEARNING SCIENCE TOGETHER: NATURALISTIC AND EXPERIMENTAL STUDIES

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DESCRIPTION OF SCIENCE COURSES FOR PARENTS AND CHILDREN

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During the 1960's and 1970's, a number of family learning projects evolved, most of which focused on preschoolers and their parents. The goal of some of these programs was to provide enjoyable structured experiences in which parents and their children learned together. Recently, a number of institutions have begun sponsoring enrichment science classes or learning experiences for parents and older children. A series of courses in animal behavior, night-time astronomy, ecology, microcomputers as well as a course in telegraphs, telephones and radios have been developed and successfully taught to parents and their middle school aged children by University of Minnesota staff with funds from the National Science Foundation (Grant #78720). These classes were designed to 1) increase the scientific knowledge of participants, 2) promote a positive attitude toward science and 3) strengthen family relationships by increasing the amount of time that parents and their middle school aged children spend together. The research studies that will be reported will be the result of two experimental studies and a naturalistic study.

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A COMPARISON OF ACHIEVEMENT AND ATTITUDE OF CHILDREN TAKING A SCIENCE CLASS WITH THEIR PARENTS AND CHILDREN TAKING THE CLASS WITH PEERS

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The purpose of this study was to investigate the effects of pairing parents and their middle school-aged children as learning partners in an informal science course. Forty-eight families who volunteered to attend a Saturday class in building radios, telegraphs and telephones were randomly divided into two groups. The first treatment group (P/C) consisted of parents and children attending the class together. The second treatment group (C/C) consisted of only children from the volunteer families. All children were also classified by their prior knowledge of the subject matter.

Using MANOVA analysis techniques, it was found that the P/C group children scored significantly better on attitude toward partner, children in the C/C group scored significantly better on attitude toward the course, and no significant differences existed between the groups based on the cognitive posttest, the perceived skill test, or on attitude toward subject matter.

Prior knowledge was a significant factor in the cognitive posttest scores and in the attitude toward subject matter. It was non-significant in the other three dependent variables.

Observers also recorded random samples of the children's verbal interactions. P/C children spent more time talking about task or management related topics while C/C children spent more time talking socially. P/C children talked more to their partner (parent) while C/C children talked more to children other than their partner and talked more to the teacher. P/C children also asked more questions, while C/C children made more supportive/praising statements to others.

A NATURALISTIC STUDY OF CHILDREN AND THEIR PARENTS IN FAMILY LEARNING COURSES IN SCIENCE

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The social interaction and cognitive processes and outcomes of parents and their middle school children during family learning courses in science were observed and described. Pre-course questionnaires indicated that children take family learning courses in science because of their anticipated interest in, enjoyment of, and opportunity to learn the subject matter of the course. Parents take the course in order to spend time with their child, to benefit the child, or because of their child's interest in the subject matter of the course.

Observer data indicated the most frequently occurring verbal interaction between parents and their children concerned the subject matter of the course and indicated that prior knowledge of the subject matter of the course was positively correlated to the amount of talk by parents concerning subject matter of the course.

Both parents and children reported in post-course questionnaires that their most rewarding experience was learning the course content. The second most frequent response by parents was the benefit of the course to their child.

Children responded most frequently that they liked taking the course with their parent because their parent gave them help and shared in the enjoyment of the course. Parents responded most fequently that they liked taking the course with their child because it was a shared learning activity. Children's most common response to what they found out about their parent by taking the course together was information about their parent's knowledge of the subject matter of the course. Parent's most common response to what they found out about their child was knowledge about their child's learning behavior.

A COMPARISON OF ACHIEVEMENT AND ATTITUDE OF CHILDREN WHO VOLUNTEER TO TAKE A MICROCOMPUTER COURSE WITH THEIR PARENTS AND WITH THEIR PEERS

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The purpose of this quasi-experimental study was to determine if middle school aged children who volunteer to take a short microcomputer course with their parents differ in achievement and attitude towards computers from children who volunteer to take the same course with their peers.

The 62 subjects in this study (average age = 12.3 years) were from two locations: Athens, Georgia, and Seattle, Washington. Analysis of extensive background questionnaires given to the parents and children in both treatment groups indicated that the children from the two locations differed in only one respect: children from Seattle had more prior experience with computers in school than had children from Athens.

The children were administered a 15-item pre and post cognitive test (reliability = 0.65) and a 17 item pre and post attitude towards computers test (reliability = 0.85). The results of the 2 (locations) x 2 (treatment) analysis of covariance tests showed no significant interaction or main effects for achievement or attitude. It appears that children who volunteer to take a microcomputer course with their parents are not significantly different in achievement or attitude towards computers from children who volunteer to take the same course with their peers.

Session G-2

RESEARCH WORKSHOP

VEE MAPPING AS A RESEARCH TOOL

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The purposed workshop will present philosophical and psychological concepts that underlie Gowin's Vee heuristic. This heuristic has been shown to aid students in secondary and tertiary schools to understand the nature of knowledge and knowledge production (metaknowledge). The Vee has been utilized as a metaknowledge tool in all disciplines (from coaching basketball or music composition to chemistry and mathematics) and results indicate that it contributes significantly to student understanding of knowledge structure and production in these fields.

The workshop will include practice work by all participants to apply the Vee heuristic to a sample inquiry and to their own area of research. Overhead transparencies with sample Vees constructed by participants will be projected and discussed. Participants should be able to begin use of this metaknowledge learning tool in their own teaching and research work after active participation in the workshop.

Session G-3

COGNITIVE SCIENCE AND SCIENCE EDUCATION--A SYMPOSIUM

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Background

In 1956 G. Miller published an information processing account of the limited capacity of short-term memory; N. Chomsky published an analysis of transformational grammars; J. Bruner, et. al. published a theory of cognitive strategies as "mediating constructs", and A. Newell and H. Simon published a description of a computer program that solved problems by heuristic search. According to Nobel laureate, Herbert Simon, that year can be taken as the birth of cognitive science, which is a study of the human mind in terms of information processing.

In 1964, research in science education was "officially" recognized as an important function with the first issue of the Journal of Research in Science Teaching. Throughout the decade of the 1970's the research reported in JRST on science learning and cognition was strongly influenced by Piaget's work. However, some research, particularly studies dealing with formal operational thought, began to raise questions about the adequacy of Piaget's theory as "the" paradigm for science learning research. The 1978 ERIC publication, "Developmental Implications of Science Teaching: Early Adolescence" by W. Wollman discusses some of these questions and suggests a "neo-Piagetian" theory of development and resultant implications.

Cognitive Science appeared in 1977 as a multidisciplinary journal of artificial intelligence, psychology, and language. A small number of science education researchers began to look carefully at the work of these "information processors" with growing interest and in 1982 a paper with the title, "Information Processing Psychology: A Promising Paradigm for Research in Science Teaching" by J. Stewart and J. Atkin was published in JRST. Also in 1982 the National Research Council, in collaboration with the National Academy of Sciences, published its second "Outlook for Science and Technology." The fourth chapter is devoted to the emerging "science of cognition."

These events, plus many others that could be identified if space permitted, suggest that science educators should begin to look more carefully at the work of these "cognitive scientists" for ideas which might be of help to us.

The Symposium

Each symposium participant will present ideas about how cognitive science might have implications for science education research. Topics to be discussed in the symposium include:

1) problem solving heuristics in science;
2) the role of short and long term memory in science learning;
3) computer simulation of scientific problem solving;
4) using "thinking aloud" strategies for research;
5) the role of belief systems, consciousness, and motivation in future research;
6) information processing as a new paradigm or an extension of other psychological paradigms;
7) the place of language in science learning.

OVERVIEW OF "COGNITIVE SCIENCE AND SCIENCE EDUCATION" - A SYMPOSIUM

The purpose of this symposium is to provide an open forum to discuss the relationship of cognitive science to science education. Each panel member will present ideas about one or two specific topics in current theory and research in cognitive science as well as discussing the more general question, what does cognitive science have to offer to science education?

A brief description of the qualifications and role of each of the symposium participants follows:

Dr. Berger. A past president of NARST, Dr. Berger has been interested in information processing and the applications of microcomputers to the learning of science process skills. His work in that area and in the implications of paradigm - based research have been communicated throughout the science education community. Dr. Berger's role in the symposium will center around two areas: 1) problem solving heuristics and computers, and 2) cognitive learning styles and problem solving. One of the more recent problem solving programs is the BACON series, developed by Simon and colleagues at Carnegie Mellon University. BACON. 5, the most recent of the series of programs, is data driven and contains five heuristics: 1) noting constancies, 2) finding linear relations, 3) detecting monotonic trends, 4) postulating intrinsic properties, and 5) analogy. Ten laws of physics are discovered by the BACON. 5 program using these five heuristics (e.g. ideal gas, Coulomb, Kepler, Ohm). The implications of such artificial intelligence programs as well as other types of computer usage in science education will be discussed.

Dr. Lawson: The author of numerous articles based on the "Piaget paradigm," Dr. Lawson is well known to the science education research community. His research has been widely reported in JRST, Science Education, and various psychology journals. During recent years he has considered the roles of motivation, attitudes, values, creativity, and consciousness in general to cognitive developmental theory and science learning. Also, the importance of the role of science subject matter in learning processes, particularly in concept formation, has been elucidated in a paper in a recent AETS yearbook.

Dr. Lawson's emphasis in the symposium will be on the relationships of consciousness and internalized language to problem solving.

Most of the work in cognitive science to date has not considered carefully the roles of consciousness or internalized language in effectiveness in problem solving.

The role of consciousness, in particular, has been considered primarily by the more philosophically-minded workers in cognitive science, although now such leaders as Donald Norman are calling for a broader view of cognitive science, one that includes belief systems, consciousness, emotion, etc., as important factors in the regulatory system of the thinking individual.

Dr. Renner: Also a past president of NARST, Dr. Renner is well known for his cognitive assessment work and its applications to science teaching. Well known are his books and papers describing interview protocols and how such research relates to teaching and learning science. One of the more comprehensive research projects in science education was originated and coordinated by Dr. Renner. This carefully designed project is described in a comprehensive research report which documents, among other things, the relationship of cognitive characteristics of secondary students to language usage in problem solving. Recent work has allowed Dr. Renner to look carefully at examples of naturalistic interview techniques used in various settings around the U.S. His role in this symposium will involve describing observations and thoughts on thinking aloud strategies for research and the place of language in science learning. The thinking aloud strategy has been the main research tool of those interested in problem solving processes by novices and experts in physics, mathematics, genetics, etc. As a research strategy for science education researchers, it is a very different approach than the widely used psychometric approach. Most observers agree that Piaget's influence has been considerable in causing this change to develop.

Dr. Stewart: One of the most active science education researchers during the 1980's, Dr. Stewart has written often and well about information processing as a paradigm to be considered seriously by science educators. He has used both research results and models to communicate important ideas about information processing to the science education community. A recent model that he has developed on the meaningful solution of classical genetics problem describes the solution requirements in terms of procedural steps and conceptual knowledge. The cognitive science "tradition" of the work of H. Simon, A. Newell, J. Larkin, J. Greeno, and others is used as a framewok for Dr. Z's work in studying genetics problem solving.

As a symposium participant, Dr. Stewart will describe the framework of information processing and explain how research into meaningful scientific problem solving might proceeed. Because of his recent published contributions on information processing as a paradigm to be considered by science education researchers, it is anticipated that Dr. Stewart will be the first presenter, defining cognitive science in general and using his work as an example of possible applications to science education.

Symposium Originator and Chair:

Ron Good will communicate by phone and letter during the next few months with the symposium participants to ensure a coordinated effort and to produce a paper on cognitive science and science education for those attending the symposium. During the symposium, he will introduce each speaker and see that no more than 40 minutes are used for the presentation so that some time will be available for questions and comments from the audience.

Session G-4

THE EFFECTS OF MASTERY INSTRUCTION ON THE LEARNING AND RETENTION OF SCIENCE PROCESS SKILLS

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The effectiveness of mastery instruction to an equivalent time non-mastery mode of instruction for improving students' learning and retention of selected science process skills was the subject of this study.

Ninety students from a suburban middle class junior high school in New York served as the subjects for the study. Comparisons in student achievement and retention were made between mastery-instructed classes and non-mastery instructed control groups. No significant differences were found in levels of achievement between mastery and non-mastery average or above-average students. Above-average mastery instructed subjects scored significantly higher than did their non-mastery counterparts on an instrument measuring retention of low level process skills; but average mastery-instructed subjects did not show any significant differences in retention from average non-mastery subjects. Both average and above-average mastery-instructed subjects scored significantly higher than their non-mastery counterparts on an instrument measuring retention of higher level process skills. While mastery instruction may not be significantly better than non-mastery instruction in effecting achievement gains when equal amounts of time are spent in both modes of instruction, the mastery instruction strategy can produce a more permanent mastery of sequentially organized materials than can an equivalent time non-mastery instructional strategy.

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Session G-4

THE EFFECTS OF A MASTERY LEARNING STRATEGY ON DIFFERENT COGNITIVE LEVELS OF ACHIEVEMENT OF HIGH SCHOOL CHEMISTRY STUDENTS

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A mastery learning strategy with a non-mastery control group was used in first-year high school chemistry. Three achievement tests were used; each achievement test was divided into knowledge, comprehension, application, and analysis level (Bloom's Taxonomy) subtests. Analysis of variance was used to determine the effects of the mastery learning strategy across these subtests. Results were mixed. Knowledge and comprehension level achievement was generally greater for the mastery learning group. Application level achievement was greater for the mastery learning group on only one of the subtests. These results indicate that much of the achievement gains noted in mastery learning studies may be coming from lower level cognitive achievement.

Session G-4

INDIVIDUALIZED AUDIO-TUTORIAL INSTRUCTION IN HIGH SCHOOL BIOLOGY (RESEARCH SUMMARY)

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The Individualized Audio-Tutorial (IAT) method as it was developed by Postlethwait consists of a set of structured learning activities in which a student pursues individually at his own rate. Most of the implementation and research with IAT was done at the college level, and few for the Junior and High School studuents (JHSS). Findings could be categorized in two clusters: 1) Cognitive domain- and 2) Affective domain.

Cognitive Domain. Results regarding academic achievements do not show a consistent trend. In kibbutzim schools, (N=84) students instructed by IAT obtained significantly higher scores than students taught by a conventional classroom-laboratory method (CCLM); and girls' achievements were improved and even higher than those of boys. A similar study with city school students (N=180) and utilizing analysis of co-variance, yielded no significant differences between the experimental and control groups, and no differences between boys and girls. In the city sample, a linear relationship was found between students' level of IQ (three sub-scales), academic levels in Mathematics, and Biology, and grades obtained by JHSS taught by IAT.

In the affective domain, JHSS from kibbutz school expressed positive attitudes regarding self examination, use of audio-visual media, student-teacher interactions, and development of independent thinking. Girls had more positive attitudes toward the individualized aspects of the IAT method, learning achievements and learning rate, than boys. Similar results were obtained in the city sample.

Attitudes toward science and understanding the process of science were measured using the Moore and Sutman instrument. Results show that the experimental group expressed significantly more positive attitudes than the control group, mainly in the emotional subscale, in the kibbutz sample, but no differences were found in the city sample.

Using classroom learning environment scale, no differences were found between mean scores of post-assessment of the two groups.

Discussion. The different results are analyzed on the hypothesis that these findings could be attributed to the difference in nature and structures of kibbutzim and city schools, as well as on the issue of teachers' behaviors and classroom management expectations.

Session G-4

MASTERY LEARNING IN COLLEGE CHEMISTRY

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This study examined two major areas: (1) the identification of those students usually considered underprepared for university level chemistry, and (2) the development and implementation of a mastery principle based instructional design in the general college chemistry for these students.

A field experimental research design was used for 63 students in a treatment group, identified by their relatively low cognitive pre-measures, and 329 students in a comparison group, who were a part of a 1,200 member traditional class. A mastery principle based instructional design was developed for the treatment group, and the progress of students from both groups was followed during their first term in general college chemistry. The mastery strategy focused on the alterable variables: time on task, formative evaluation and highly structured teaching.

Educational gain was demonstrated for the treatment group since the two groups were found significantly different in cognitive entry level but significantly similar in educational outcomes measured in terms of course grades and student satisfaction.

Session G-5

EVALUATION OF AN INSERVICE TEACHER TRAINING PROGRAM FOR ENERGY EDUCATION

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This evaluation assessed the effectiveness of an inservice teacher training program. The program provides inservice training in a stepwise fashion by recruiting teachers from local districts to attend an intensive training institute and then having these teachers offer similar courses for their colleagues.

The evaluation was divided into three sections; a qualitative component that provided a portrayal of the program through the triangulation of various data sources (e.g., interviews, observations); a quantitative component that examined impact through pre-post paired t-test results from program participants on three instruments (Energy Opinionnaire (EO), Beliefs about Science and Science Education (BSSE), Curriculum Attitude Survey (CAS); and a comparative component that compared program participants with "typical" teachers from a random sample through on the EO and the CAS. Students of program participants and random sample teachers were also assessed using a modified EO, an Energy Survey and the Learning Environment Inventory. Results show that the program was effective but that some improvement is possible. Additionally, information on teacher and student attitudes towards energy conservation and knowledge of energy facts, and teacher beliefs about teaching science and attitudes towards curricular change is provided.

Session G-5

CONSTRUCTING ONE-SIDED AND TWO-SIDED COMMUNICATIONS FOR USE IN PERSUADING PRESERVICE TEACHERS OF THE IMPORTANCE FOR INCLUDING ENERGY CONSERVATION TOPICS IN THE ELEMENTARY SCHOOL CURRICULUM

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The purpose of this study was to construct both one-sided and two-sided communications designed to persuade preservice elementary teachers of the importance for including the topic of energy conservation in the elementary curriculum. Following the identification of appropriate communicator characteristics by categorizing the responses of 113 elementary teachers and the skeleton of the communication by categorizing the responses of 35 science educators, both one-sided and two-sided communications were constructed.

The results of data analysis from 45 preservice elementary teachers revealed that the two communications, while similar regarding supportive arguments, were significantly different with respect to non-supportive arguments. The implication being, that persuasive communications designed for audiences of differing levels of developmental advancement within the domain of energy conservation stand ready to be tested.

Session G-5

DEVELOPMENT AND VALIDATION OF A BARGAINING, COHESION AND COOPERATION ENVIRONMENTAL DECISION-MAKING ATTITUDE ASSESSMENT INSTRUMENT

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This study reports on the development of the Decision Making Attitude Assessment Instrument which assesses the effects of environmental decision-making curricula on the decision-making attitudes of bargaining, cohesion, and cooperation of college students.

From an initial item pool content validity for 25 statements was established by a panel of experts knowledgeable in decision-making and attitude scales. These 25 statements were ordered into a Likert-type scale and administered to environmental science students at a major university (N=128). The most highly correlated statements were selected, reworded, doubled, and readministered to additional environmental science students (N=104).

A total scale reliability coefficient of .834 with reliability coefficient of .797 for the cooperation subscale, .706 for the bargaining subscale, and .538 for the cohesion subscale.

Moderately high subscale correlations indicated that a possible relationship exists among the subscales and that these attitudes may not represent independent constructs.

In summary, a reliable instrument was developed which can be used by classroom teachers and researchers to assess the environmental decision-making attitudes of bargaining, cohesion, and cooperation of college students. It is recommended that the instrument could be used to assess other decision-making curricula and student populations.

Session G-5

USING THE CBAM TO PREPARE ELEMENTARY SCHOOL TEACHERS TO TEACH ENVIRONMENTAL SCIENCE

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There are many gaps in the professional preparation of preservice elementary school teachers. A major area in which preservice elementary teachers receive little or no experience is science. Fewer have any experience in environmental science. More training and preparation in the sciences are necessary if both the quality and quantity of science instruction is to improve. If this problem is not attacked at the preservice level, then it must be implemented at the inservice level.

This paper reports a year-long effort designed to improve inservice teachers' knowledge of environmental science and attitudes toward environmental science education. The Concerns Based Adoption Model (CBAM) was used to design and implement an instructional program to meet teacher-perceived concerns and needs. Assessment techniques as well as research techniques undertaken and the instruments used for collecting data on teacher change are discussed. Results of the program on teacher development and change are reported.

Session G-5

THE IMPACT OF MULTIDISCIPLINARY MARINE EDUCATION CURRICULUM INFUSION MATERIALS ON SCHOOLS AND TEACHERS IN MAINE AND NEW HAMPSHIRE

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This study was designed as an evaluation of the impact of the Northern New England Marine Education Project infusion curricula on school principals, science department heads and teachers in grades K-12 in the states of Maine and New Hampshire. This summative evaluation was conducted by using mailed questionnaires sent to all 246 secondary school science heads and a random twenty percent sample of principals of grade K-6 schools. Two questionnaires were employed: one for principals or heads, the other for teachers. Supervisors returned 142 questionnaires while teachers returned 320 replies. Data reduction and Chi-square analyses were conducted using the SPSS sub-program CROSSTABS. Major findings indicated that Project materials were used at approximately the same percent at all grade levels represented. Approximately 33% of the schools were aware of the Project materials and of those, 75% were using them. Inservice education and proximity to the sea were major predictors of use.

Session H-1

IMPORTANCE OF STUDENT/STUDENT INTERACTION

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Twelve studies examining the effects of cooperative, competitive and individualistic student interaction patterns on acceptance of differences and achievement in science classrooms were summarized. The subjects ranged from middle elementary school through junior high in the different studies and were from both inner city and suburban classrooms. The inner city settings were multi-ethnic and all settings included handicapped and nonhandicapped students. The studies lasted from ten days to six weeks with most covering three weeks or more. All studies followed a field-experimental research pattern with subjects randomly assigned to condition, rotation of teachers and use of identical curriculum. The results of the studies indicate that nothing is lost in terms of achievement with half the studies showing significantly higher achievement scores for students in the cooperative condition and the other half, no significant differences. All the studies indicated that acceptance of differences is higher in a cooperative setting than in competitive and individualistic settings and that students in cooperative relationships with each other feel more supported by peers and teachers.

Session H-1

THE EFFECTS OF MIXED-SEX AND SINGLE-SEX COOPERATIVE GROUPING AND INDIVIDUALIZATION IN SCIENCE ACHIEVEMENT, ATTITUDES, AND VERBAL LEADERSHIP OF EARLY ADOLESCENT FEMALES

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Female students have lower achievement and less positive attitudes in science than do male students. This difference is larger in the physical sciences and becomes greater as students grow older. This study examines the effects of mixed-sex and single-sex cooperative grouping and individualization on the science achievement, attitudes, and verbal leadership of early adolescent females working in physical science.

The subjects, 154 (76 female and 78 male) fifth and sixth grade students, were assigned to one of three conditions using a stratified random sampling procedure controlling for ability, grade, and sex. Students worked for nine weeks on an electricity unit. Observers coded verbal interaction almost daily. An achievement post test and four attitude scales (Liking Science Study, Science Utility in Career and Life, Confidence in Science Ability, Science as a Male Domain) were given individually at the end of the study.

A MANOVA with two contrasts (cooperative versus individualistic, and mixed-sex cooperative versus single-sex cooperative) indicates that there were no significant differences in achievement between the three conditions and there were no differences in attitudes between individualistic and cooperative conditions. However, single-sex cooperative females had more positive attitudes toward science study than did mixed-sex cooperative females. Conversely, the females in the mixed-sex cooperative condition has more positive attitudes toward the female role in science. There were no differences in the female verbal leadership.

Session H-1

USE OF CLASSROOM ENVIRONMENT SCALE IN INVESTIGATING EFFECTS OF PSYCHOSOCIAL MILIEU ON SCIENCE STUDENTS' OUTCOMES

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Associations were investigated between student perceptions of classroom psychosocial environment, as measured by the Classroom Environment Scale (CES), and their achievement of nine affective and cognitive aims, as measured by the Test of Science-Related Attitudes (TOSRA) and the Test of Enquiry Skills (TOES). The sample consisted of 1083 junior high school students in 116 science classes. Preliminary analyses attested to the validity and usefulness of the CES in science education by establishing each scale's internal consistency, reliability, discriminant validity, and ability to differentiate between the perceptions of students in different classrooms. In investigating environment-outcome relationships, the class mean was employed as the unit of analysis and data were subjected to six different statistical analyses (namely, simple correlation, multiple correlation, and canonical correlation analysis conducted separately for raw posttest scores and residual posttest scores adjusted for corresponding pretest and general ability). The results of these different analyses taken together confirmed the existence of sizeable and statistically significant associations between student learning outcomes and their classroom environment perceptions as measured by the CES.

Session H-2

DEVELOPING AN ATTITUDE SCALE TOWARD THE TEACHING OF CHEMISTRY

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The purpose of the study was to develop a reliable and valid Likert-type attitude scale toward the teaching of simple chemistry concepts in the elementary school.

Using Edwards' (1957) 13 validation criteria a pool of 60 statements were written, randomized, and administered to 64 preservice elementary teachers. The data were subjected to a Likert analysis and a principle-components factor analysis.

Statements with an item-total correlation coefficient of .30 or less and 25% or more undecided responses were either rewritten or dropped. Twenty statements, 10 negative and 10 positive ones, withstood those tests. A three-factor analysis was chosen to check the investigator's classification of statements into three categories: egocentric, sociocentric and action-centered. Using a three-factor solution, a varimax rotation resulted in 18 of the 20 items loading on one of the three factors. Factor 1 accounted for 25.92%, factor 2, 11.45% and factor 3, 7.28% of 44.02% of the total variance. Fifteen of the 18 clustered into the three areas as predicted by the investigator.

When administered again to 98 subjects the average item-total correlation coefficient (adjusted) was .59, and the reliability coefficient alpha was .91.

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Session H-2

THE RELATIONSHIP OF FIELD INDEPENDENCE, DOGMATISM, TOLERANCE FOR AMBIGUITY, AND KNOWLEDGE OF SCIENCE PROCESSES TO THE DEVELOPMENT OF POSITIVE ATTITUDES TOWARD SCIENCE AND SCIENCE TEACHING

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Research into factors that are related to the development of positive attitudes toward science and science teaching during an inquiry-oriented science methods course had indicated that the cognitive styles of field independence and tolerance for ambiguity are controlling variables. Less certain is the relationship of the cognitive style of dogmatism and knowledge of science processes to this development.

This study was designed to further investigate the relationship of cognitive style and knowledge of science processes to the development of positive attitudes during an inquiry-oriented science methods course stressing the philosophies, designs, and activities of various NSF elementary science curricula.

The subjects included 30 preservice and inservice elementary school teachers enrolled in an elementary science methods course at Rutgers University. The sample included males and females of various ages, but analyses of variance showed the dependent variables to be unrelated to gender, and age was not significantly correlated with any variable.

The design involved a pre- and post-test of attitudes toward science and science teaching with a measure developed by Moore (1973). Cognitive styles were assessed through the use of the Embedded Figures Test (Witkin, 1971), the Tolerance-Intolerance of Ambiguity Scale (Budner, 1962), and the D-Scale (Rokeach, 1960). Knowledge of science processes was measured by the SAPA Pretest for Science Teachers.

Simple and multiple regression were employed in the analysis of the data. The latter method permitted an assessment of the variance in post-test scores with the pretest variance controlled and thus provided a closer assessment of relationships to actual development in attitudes among subjects.

First-order correlational analysis indicated that tolerance for ambiguity was significantly related to pre-and post-test attitudes toward science and science teaching and that knowledge of science processes was significantly related to pre-and post-test attitudes toward teaching science. Multiple regression analysis refined these findings to indicate that tolerance for ambiguity by itself explained 10% of the variance in pretest attitudes toward science and, in combination with knowledge of science processes, explained 21% of the variance in pretest attitudes toward teaching science. These variables, however, proved to be unrelated to the development of positive attitudes.

Only field dependence emerged as a significant relationship with post-test scores when pretest scores were controlled; field dependence was related to the development of attitudes toward science, explaining 7% of the residual variance. This relationship was the opposite of what had been anticipated.

This study indicates that, for this sample, the subjects' tolerance for ambiguity and knowledge of science processes were both related to their attitudes when they began the course and when they finished the course, but these variables did not seem to affect the development of the desired attitudes during the course. Field dependence was related to the development of attitudes toward science, although this finding is counter to that of other research in this field and so may represent sampling error. Further research is necessary to substantiate these findings, to determine whether or not other cognitive styles are more important in the development of positive attitudes, and to confirm that previous training in science processes can affect attitudes toward teaching science.

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Session H-2

ANXIETY ABOUT TEACHING SCIENCE AND ATTITUDE TOWARD TEACHING SCIENCE AMONG INSERVICE ELEMENTARY SCHOOL TEACHERS

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This paper describes a research study designed to identify factors which contribute to the avoidance of science teaching among inservice elementary school teachers. In particular the relationships among amount of science taught, teachers' anxiety about teaching science, teachers' perception of the importance of science, and other demographic information were investigated. A questionnaire was employed to gather attitudinal and demographic data from 70 inservice elementary school teachers, while a modified form of Spielberger's State-Trait Anxiety Inventory was used to provide a measure of anxiety about teaching science. Analysis of data suggests that one of the major factors associated with teachers' classroom practice related to science is their perception of the importance of the subject. While the effect of anxiety about teaching science on teachers' behavior is not clear from this study, it is apparent that science teaching is, for many teachers, an anxiety-provoking experience. One factor that appears to be related to science teaching anxiety is science background, although this does not appear to be related to the amount of science taught. The investigators offer some suggestions for the structuring of preservice and inservice elementary teacher training.

Sesson H-4

HIGH SCHOOL CHEMISTRY STUDENT PERCEPTIONS OF THE LABORATORY AND CLASSROOM

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This study examined differences between student perceptions of the classroom and laboratory in high school chemistry. It investigated effects of individual student characteristics and different types of activities on student perceptions of the learning environment.

Students' perceptions of the classroom were found to be more goal directed, more satisfying, and less competitive than were their perceptions of the laboratory. Inquiry activities were perceived by students to be more cohesive but less satisfying, less organized, and less difficult than traditional activities. Gender and differences in grade level caused little variation in student perceptions of the learning environment.

Average and high ability students perceived their learning environments similarly. Low ability students perceived their learning environments to be more cohesive, slower in pace, less satisfying and more difficult than did students in classes of average ability. Students in classes of low ability perceived the learning environment of the laboratory to be more difficult than that of the classroom.

Session H-4

EFFECT OF INCREASED LABORATORY TIME ON SELECTED STUDENTS' ATTITUDES TOWARD SCIENCE

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The purpose of the present study was to determine the effect of increased laboratory time on selected students' attitudes toward science.

The students involved in the study were 42 New York City high school juniors registered in a general chemistry course. The New York State General Chemistry Syllabus, rather than the more challenging and comprehensive Regents Syllabus, was followed.

The sample of 42 students was divided into two sections, one consisting of 22 students, and the other of 20 students. Both sections were taught by the investigator. The students were slightly below average in both reading and mathematics standardized scores. All the students came from the New York City area, and travelled to the school by public transportation. They were of a middle socio-economic background. The entire sample for the study was female, since the high school is an all-girls school.

The Science Attitudes Appraisal was administered to the sample in March, 1982, and again after students' laboratory time had been increased from 20 percent to 40 percent of chemistry time. The Science Attitudes Appraisal consists of a total of 60 items.

The experiment lasted for six weeks. T-tests were used to evaluate the null hypothesis, "There is no change in selected chemistry students' attitudes toward science when they experienced increased laboratory time."

The pre-test mean for the entire sample was 221.52, while the post-test mean was 218.48. The null hypothesis could not be rejected. There was no change in selected students' attitudes toward science, despite increased laboratory time!

Sesson H-4

A NEW SCIENCE AND ENGINEERING CAREER INTEREST SURVEY FOR JUNIOR HIGH SCHOOL STUDENTS

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The paper describes the development and validation of a science and engineering (S/E) career interest survey (CIS). This 56 question survey was developed to measure the overall S/E career interests of junior high school students (Grades 7 through 9). In the CIS, a S/E career is characterized as one which requires the completion of at least a four year college program with a major in science, science education, or engineering. The CIS is divided into four major parts, with parts 1 through 3 using multiple choice quesitons and part 4 asking the student to name his/her actual job interest. In part 1 (30 questions) students are expected to select the occupational activity they would like to do the most, while in part 2 (20 questions) they are to select from various occupations. Part 3 (5 questions) and part 4 together make up the CIS verification score. The CIS test-retest reliability over a one week period was .96 (N=57). Concurrent validity coefficients were calculated in two ways: (a) CIS scores were correlated with the Kuder GIS science subscale (r=.75, N=45), and (b) CIS scores were correlated with a CIS verification scale (r=.59, N=127).

Session H-5

HORIZONTAL ENRICHMENT IN SCIENCE AND MATH AT THE SENIOR HIGH LEVEL

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AN ANALYTIC PROFILE OF PRECOCIOUSLY GIFTED STUDENTS ENROLLED IN HORIZONTAL ENRICHMENT PROGRAMS

Connolly-Primavera

In light of the reality of current enrichment curriculum, an answer was sought to determine if a horizontal enrichment program which prepares research projects for the Westinghouse Talent Search could be a viable alternative to Stanley's (1979) vertical acceleration approach.

Data from 590 students who qualified as semifinalists and 98 students who qualified as finalists were analyzed using multivariate analysis with regard to the following relationships: gender, ethnicity, SES, subject area of the research project, type of school and professional status of these students' parents. Also the type of school program that allowed for consistent production of semifinalists and finalists was reviewed.

Some of the findings indicate that the New York Metropolitan region accounted for 35% of total nationwide finalists: 75% of the finalists came from New York City high schools (public); and Stanley's finding of differential mathematic achievement by gender was confirmed. This horizontal program proved to be a well developed, viable alternative to a vertical acceleration approach. Implications are included for further research including the area of psychological and social development of the horizontal enrichment program students compared to the vertically accelerated student.

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Campbell

This study analyzed very successful horizontal enrichment programs in science in fifteen senior high schools. The term "successful" was defined with four criteria. Two of these criteria involved the consistent production of the student research, and two criteria concern the quality of this research. One of the quality criteria involved producing at least one finalist in the Westinghouse Talent Search. The schools in our study produced fifty-two Westinghouse finalists in just seven years. The enrichment programs were analyzed by interviewing teachers, students, administrators, and by conducting site visits.

The results of this study indicated that these programs seemed to benefit the schools as much as they benfited the gifted students. We also found that the schools' lab facilities were no better than most schools in the region. Financial commitments to the programs were also minimal. Independent investigation accounted for the day-to-day activities. The teachers engaged in these programs were oriented toward one of the sciences and updated themselves by reading the scientific journals. These teachers accumulated as few courses as possible in education and did not know any of the authorities in gifted education. In all cases they developed their programs for these gifted students from their own "hands-on" experience.

Napolitano-Campbell

This study analyzed the six most successful senior high school horizontal enrichment programs in mathematics. The term "successful" was defined by four criteria. Two of these criteria involve the consistent production of student research in math, and two criteria involve the quality of this research. One of the quality criteria involved producing at least one finalist in the Westinghouse Talent Search. The schools in our study produced twenty-seven Westinghouse finalists in math in just seven years. The enrichment programs were analyzed by interviewing teachers, students, administrators, and by conducting site visits.

The results of the study indicated that female students do not perform as well as males in the various math competitions. We found that the facilities, including the type and number of computers available, were not important factors in these programs. All of the teachers were math majors with very few education courses. They kept up-to-date by reading the math journal month by month. The programs these teachers designed focused on problems taken from these journals. Initially the students were encouraged to make contact with mathematicians at the college level and then to develop independent investigations on their own. Our study showed that these students were into every activity in their schools.

In conclusion, we found that these programs were very successful at producing the next generation of professionals.

Session I-1

DEVELOPMENT OF AN INTEGRATED SCIENCE PROCESS SKILLS TEST

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Even though the science process skills are important outcomes of many science programs, few valid and reliable tests exist for their assessment. The purpose of this project was to develop test items for assessing identification of variables, statement of hypotheses, operational definitions, design of investigations, and the display and interpretation of data. A pool of items in multiple choice format was prepared for these four outcomes and examined by experts for content validity. Field trials of the items were conducted with students in grade 7 through 12. The results of the field trial show the resulting test to have high reliability and difficulty and discrimination indices within the range of suggested test development standards. The resulting test is a resource for assessing process skill achievement in classrooms or in research and evaluation studies.

Session I-1

WHAT AFFECTS STUDENT ACHIEVEMENT IN SCIENCE?
A CORRELATIONAL STUDY

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Rationale

A review of the literature (several summaries in science education) provides information about mental factors that appear to be associated with achievement in science.

A correlational study was conducted in order to find what relationship exist between students' achievement in introductory physical science and several factors which have been found by other studies to influence this achievement: (a) the ability to think scientifically (enquiry skills), (b) curiosity, (c) gender, (d) locus of control, and (e) grade in school.

Method

The research was conducted on 237 7th and 8th grade students in junior high schools in Israel. Three tests were administered: Frazer's (1980) test of enquiry skills, Campbell's (1971) test of scientific curiosity and a test designed to measure students' locus of control. Students' grades in science (given by the teachers) were also obtained.

Results and discussion

The correlations between the variables were obtained and factor analyzed. Three distinct factors were obtained. The scores on the enquiry test and students' grades in science loaded significantly on the 1st factor. The 2nd included significant factor loading of the curiosity test subscales and the 3rd included the locus of control.

In order to find out the ability of various independent variables to predict students' achievement in science, multiple regression analysis was conducted; 28% of the total variance of students' score in science was found to be explained by the score on the various skills of the test of enquiry skills. Only a small proportion of the variance is explained by the curiosity variables, students' gender and locus of control.

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FLEXIBILITY AND ACHIEVEMENT IN SCIENCE

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This study addresses the question of whether flexibility of thinking, defined as the ability to break a deliberately induced set, can be shown to be an important factor in science achievement.

An intact class of fifth grade students was instructed for six weeks in the SCIS unit Relative Position and Motion. Subsequently, they were evaluated with achievement measures developed to accompany the SCIS program, and were also administered the Group Embedded Figures Test and a group version of the Luchins Water Jar Test.

The subjects were divided into two groups, based upon their performance on the Water Jar Test. Those who were able to successfully overcome the set induced as part of that test were characterized as flexible, and those who could not were labeled rigid. Flexible subjects were significantly more successful on the SCIS achievement test and on the Group Embedded Figures Test. Neither time to completion of the Water Jar Test nor success on the Group Embedded Figures Test correlated significantly with score on the achievement test.

It appears that the ability to break set is an important component in the learning of science. Students who can put aside a preconceived solution to a problem, who are not subject to the lure of past experience or algorithms which they have learned in a different context, are more likely to be successful in the science classroom. Perhaps deliberate interventions to stimulate flexible thinking would be a productive approach to improving performance in the science class.

Session I-2

RESEARCH INTO TEACHING CHEMISTRY AND PHYSICS USING THE LEARNING CYCLE

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Prior research with the learning cycle has shown it to be a viable curriculum-organization plan and teaching strategy. The research to be discussed was not done to compare the learning cycle with other approaches but to explore its inner workings. Specifically, the research was done to answer three questions about the three phases of the learning cycle, which are exploration, conceptual invention and expansion of the idea. Those questions are:

1. Is each phase of the learning cycle necessary?
2. Is the sequence of exploration, conceptual invention and expansion of the idea the only and/or best sequence for the students to experience the phases?
3. Does the form of delivery of the instruction in the learning cycle influence the achievement of the students?

A total of fourteen special experiments--seven in each senior high school chemistry and physics--were designed to test the necessity, sequence and form variables. The planning, execution and interpretation periods of the research required 20 months. The research team consisted of three professors of science education and three senior high school teachers of physics and chemistry.

The results of using validated content tests and a validated attitude inventory will be presented. The validation process will also be discussed. The conclusions drawn regarding the form, necessity and sequence variables will also be presented.

Session I-3

THE EFFECTS OF RELATING PERSONAL EXPERIENCES THROUGH NARRATIVE AND PROMPTING ON THE RECALL OF PHYSICAL SCIENCE CONCEPTS

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In a recent assessment of the needs in science teaching supported by the National Science Foundation, it was reported that school science programs can be characterized by one word--textbook. This can be interpreted to mean that science teachers rely heavily on textbooks and that this instructional aid may be the major source of information in many science courses. If such is the case, science teachers should be given additional help on effective usage of the textbook. A set induction narrative, developed around the personal experiences of the students, is one approach that may help students recall relevant concepts that they will encounter in their textbook based instruction.

The population for this study was all (N=165) eighth graders in junior high school. The two independent variables that were used to form the treatment groups were narrative and prompting, and resulted in the following treatments: (1) familiar narrative with prompting, (2) familiar narrative with no prompting, (3) historical narrative with prompting, and (4) historical narrative with no prompting. The test "How's Your Logic?" was used to assess students' logical thinking ability. And a 29-item paper and pencil test was used to assess students' recall of their knowledge of the selected physical science concepts.

A two by two analysis of covariance was used as the research design. The F-test results of the analysis indicated that the subjects in the familiar narrative group had significantly (p 0.01) higher scores than the subjects in the historical group, and the prompting did not appear useful. Therefore, a several page narrative may be helpful in improving eighth graders' recall of their knowledge of force, mass, weight, and acceleration. It seems to interest students in what they are reading and helps them to recall these ideas.

Session I-3

A SINGLE SUBJECT DESIGN TO TEST SELECTED SCIENCE PROCESS LEARNING WITH MENTALLY HANDICAPPED CHILDREN

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This study determined the rate of improvement of selected mentally handicapped students to comprehend two basic scientific processes--serial ordering and pattern building.

Subjects consisted of eight mentally handicapped students.

Experimental single subject design was used. The time series consisted of 15 consecutive days and two follow-ups. The research hypotheses under investigation were:

> There will be a difference in the learning curve and on the number of trials a participating student needs to place rods in sequential order, before and after the investigator's intervention.
>
> There will be a difference in the learning curve and on the number of trials a participating student needs to form selected patterns before and after the investigator's intervention.

A total of 56 learning activities was illustrated and hypotheses were supported or not supported in each instance. The research hypotheses were supported in 39 instances, not supported in 7 instances, and neither supported nor not supported in 10 instances due to lack of conclusive evidence.

The major conclusion drawn was that:

> Teaching progressively and from simple to complex seemed effective. Once a student learned a simpler task, a more complex but related one became easier, i.e., once ordering one to four cubes was learned, extrapolation was not a learning problem.

Session I-3

DEVELOPMENT OF SERIATION AND ITS RELATION TO THE ACHIEVEMENT OF INFERENTIAL TRANSITIVITY

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Sixty kindergarten and first grade children took part in an intervention program during which they were confronted with problems requiring concrete operational thought. The study was designed to ascertain the influence of an intervention in the development of operational seriation and transitivity in kindergarten and first grade children who initially failed to demonstrate the ability to do seriation and transitivity problems. Seriation of size, presumably a prerequisite operation for transitive size relations, was also studied. The subjects showed significant advancement toward concrete operation on the seriation problems but failed to show significant improvement on the transitivity problems. In addition, subjects who showed understanding of transitive inference also demonstrated success on seriation, but subjects who showed clear understanding of seriation did not demonstrate success on making transitive inference. Results were interpreted in the context of Piaget's equilibration theory.

Session I-4

CLASSROOM VERSUS FIELD TRIP SCIENCE EXPERIENCES: IS ONE BETTER FOR LEARNING?

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Fourth grade children (N = 171) were presented with a structured lesson regarding aquatic mammals, either as part of a field trip to a zoological park or as an in-class slide lecture. The script for the lesson was identical for both the zoo tour and the class presentation. Learning and retention were assessed by giving a pre-test two weeks prior to either the zoo tour or class presentation, a first post-test four days after the experience, and a second post-test approximately 60 days later. Results indicated significant learning and retention for all subjects. However, the zoo tour group showed much more learning than did the class presentation group. A subsample of zoo tour subjects who did not see all the target animals showed an intermediate level of performance. Findings are discussed in terms of the role of relevant contexts in facilitating cognitive learning.

Session I-4

THE COMPARATIVE EFFECTS OF DIFFERENT MUSEUM TOURS ON CHILDREN'S ATTITUDES AND LEARNING

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Various studies contradict each other on the value of field trips and museum visits to improve learning and attitudes. This study involved 816 students in 31 tours of the newly opened Natural History Gallery of the British Columbia Provincial Museum in Victoria. The study concluded that students of grades 5, 6, and 7 had significantly greater cognitive learning when they participated in a more structured tour, i.e., one led by a museum docent. On the other hand, students of grades 5, 6, and 7 had significantly more positive attitudes when they participated in the less structured tour, i.e., one guided only by their classroom teacher.

Session I-4

FAMILY INVOLVEMENT IN ELEMENTARY SCIENCE: A SURVEY OF PARENTS

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Although parents have been involved in their children's education in science in many ways, there has been a recent trend by schools and science centers to increase parental involvement in science. New editions of some elementary science series also have made provision for involving parents in science by including take-home activities in each unit.

Despite the many efforts to involve parents, very little is known about learning in family groups. The purposes of this study, therefore, were to involve parents in take-home activities, to solicit information about their participation and to test the relationship of several variables to the percent participation of parents.

Thirty-two student teachers in urban and suburban schools, 15 inservice teachers in urban schools only, and 1,357 students and their families were involved in the study. An accompanying questionnaire to the take-home activities was used to gather data from the parents. Conventional frequency statistics were used to analyze the responses that included number and kind of family member involved, kinds of learning that occurred and previous parent-initiated science activities. Analyses of variance were used to test the relationship of several variables to the percent participation of parents.

Parent participation for student teachers in both urban and suburban schools was 61%, and for inservice teachers in urban schools only, 46%. For both groups of teachers, mothers most frequently participated, although fathers were involved in 44% (student teachers' classes) and 30% (inservice teachers' classes) of the family groups. In addition to reporting what their children learned from the activity, 44% of the parents also described what they learned or remembered as a result of participating. Additional related activities were initiated by 23% of the family groups. Ninety-four percent of the parents also reported previous, self-initiated activities to involve their children in science.

Analyses of variance revealed no significant differences in percent participation of parents when compared by grade level, amount of in-class instruction, or science discipline of the activity. However, significant differences were found in percent participation of parents by schools (p .01) and by school district (p .05).

The results of the study support the potential impact that take-home activities can have in involving parents in their children's learning in science. The results also suggest that take-home activities may have potential as a delivery mode of science education to parents, thus contributing to their scientific literacy.

Session I-5

EFFECTS OF CONTINUITY VERSUS DISCONTINUITY OF PHYSICAL SCIENCE TEACHING UPON LONG TERM RETENTION OF ANTECEDENT LEARNING

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Studies of long-term outcomes of introductory science courses are crucial for careful development of advanced courses. This paper presents results relating to one question which has been investigated in a longitudinal research project: is the retention of previously learned physical science courses facilitated by new content taught in subsequent courses?

Our study was carried out with Israeli students, who were followed for three consecutive years - from grade 8 to grade 10 (ages 13-16). The investigation was started with a nation-wide sample of 8th grade classes, consisting of two groups: both groups had studied the same introductory physical science course in grade 7, but only one continued to study physical science in the 8th grade.

The main research instrument was a multiple-choice test of science background (recall and higher cognitive skills). In addition, a questionnaire in which students were asked to declare estimates of their retention was administered. Retention was assessed by repeated testing at the 8th, 9th and 10th grades.

Multivariate analysis of covariance detected that retention of the 7th grade subject matter at the 9th grade was significantly higher in the group which had studied physical science continuously during both the 7th and 8th grades ($p=0.0002$; $N=109$ classes). Moreover, significant differences persisted at the 10th grade.

The results clearly indicate that the subsequent course had a long lasting facilitation effect upon retention of the preceding course. We wish to emphasize that although facts, concepts and principles learned at the 7th grade course are used in the 8th grade, none of them is relearned. Hence the measured facilitation effect is not due to mere rehearsal. The main educational implication is that an investment in introductory courses has larger long-term profits if their content is adjusted with those of subsequent courses. This implies that a program composed of a hierarchical sequence of learning units is superior to a discontinuous array of discrete courses.

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Session I-5

DISCOURSE PATTERNS ASSOCIATED WITH THE USE OF EXTENDED WAIT TIME IN WHOLE CLASS SETTINGS

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The study was conducted in ten intact classes in grades 6 and 7 from suburban schools in Perth, Australia.

The purpose of the study was to investigate changes in discourse attributable to the use of an extended teacher wait time in a sequence of seven lessons related to probabilistic reasoning. The results indicated that teacher wait time increased significantly over the seven lesson sequence from an average of 1.9 seconds to an average of 4.4 seconds. Discourse patterns in whole class settings also changed throughout the study. Although the total number of utterances decreased, the average length of pupil utterances increased. Changes were also observed in the teacher discourse. The most notable of these related to the type of teacher talk that followed a pupil response to a question. Teachers tended to probe to obtain further pupil input rather than mimicking pupil responses.

The results of the study have indicated that the use of an extended teacher wait time in whole class settings can improve teacher and pupil discourse characteristics. However, the changes that occur are different from those that occur when an extended wait time is used in work groups. Teachers may need to be sensitized to the differing effects of longer wait time in whole class, work group, and individualized settings.

Session J-1

PROTOCOLS, SCORING CRITERIA, AND MOTIVATION FOR PRESENTING SIX LOGICAL, SPATIAL AND FORMAL TASKS TO MIDDLE SCHOOL, HIGH SCHOOL AND COLLEGE STUDENTS

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Two studies were designed to investigate the relationships among some of the particular mental structures of logical, infralogical and formal operations. Piaget's theoretical framework predicting the order of attainment for logical groupings (dealing with seriation and classification), the infralogical groupings (for projective and Euclidean space) and the structures for the measurement group and formal schemata was used to select the six tasks. In particular, the relationship between spatial and formal reasoning was investigated to determine if concrete spatial reasoning structures are necessary precursors to formal reasoning. Detailed protocols and scoring criteria are presented to encourage comparison and replication of specific task data with those of other studies. In addition, scoring criteria for the Location of a Point in Two and Three Dimensions task for the multiplicative measurement group were refined and validated.

Session J-1

THE PERFORMANCE OF STUDENTS IN GRADES SIX, NINE AND TWELVE ON FIVE LOGICAL, SPATIAL AND FORMAL TASKS

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Approximately 100 students in grades six, nine and twelve were interviewed individually on five of Piaget's tasks. Data for each group were analyzed to look at general performance, grade level differences and gender-related differences. The data show that only 54% of the subjects passed the concrete operational seriation task, less than 20% scored at the highest level on the projective space and measurement group tasks, and only 9% or less scored at the formal level on the separation and control of variables or proportional reasoning tasks. Grade level differences were seen on the concrete operational and measurement group tasks, but there were no significant grade level differences on the formal operational tasks. No clear pattern was seen in gender-related differences. The relationship between performance on the concrete spatial and formal tasks and implications for curriculum design and classroom practice will also be discussed.

Session J-1

AN INVESTIGATION OF THE ORDER OF ATTAINMENT OF THE MENTAL STRUCTURES FOR SIX OF PIAGET'S LOGICAL, INFRALOGICAL AND FORMAL TASKS

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Piaget's developmental model includes a proposed order of attainment of the concrete operational level logical groupings (dealing with classification and seriation) and infralogical groupings (for space and time). He indicates that all these concrete structures are necessary for the development of the formal schemata. Although the relationship between the logical groupings and formal schemata has been verified, the relationship between the spatial and formal structures has not been dealt with as extensively. Three concrete operational tasks were chosen as representing the last logical, projective and Euclidean groupings to develop. A task for the multiplicative measurement group was used to check the model's prediction that these structures grow out of those of Euclidean space. Two formal tasks were also given in the individual interviews with approximately 100 college general science students.

Piaget's model predicts that the overall order of acquisition for the tasks should be: 1) Seriation Matrix; 2) Tilt of a Cone; 3) Model Landscape; 4) Location of a Point in Two and Three Dimensions; and 5) and/or 6) Bending Rods/Projection of Shadows. The data show no significant difference in performance on the two formal tasks so two separate scalogram analyses for the first four tasks plus one formal task were done. Both scalograms show that the tasks scale as the model predicts, with the concrete operational spatial groupings necessary precursors of formal thought. Implications for course and curriculum development and classroom practice will be discussed.

Session J-2

RESEARCH WORKSHOP

ASSESSMENT OF CLASSROOM PSYCHOSOCIAL ENVIRONMENT

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Recently there have been numerous developments and improvements in the instruments available for assessing student perceptions of classroom psychosocial environment. For example, instruments have been made amenable to ready hand scoring, comprehensive validation data have been generated for large samples of science classes, preferred forms of instruments have been developed (in addition to actual forms), and short forms of existing scales have been produced to provide a more rapid assessment of classroom environment. This workshop familiarizes participants with background information, scoring procedures, and validation data relevant to the Learning Environment Inventory, My Class Inventory, Classroom Environment Scale, Individualized Classroom Environment Questionnaire, preferred forms of some instruments, and short forms of some instruments. Finally, an overview is given of recent science education research involving use of these instruments (e.g., studies of outcome-environment relationships, curriculum evaluations, research into differences between students and teachers in their perceptions of actual and preferred classroom environment, person-environment fit investigations of whether students achieve better in their preferred environment, and use of environment assessment as a practical basis for guiding improvements in classrooms).

Session J-3

APPLICATION OF THE LEARNING HIERARCHY MODEL TO THE IDENTIFICATION OF SPECIFIC MISCONCEPTIONS FOR TWO SCIENCE CONCEPTS

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The use of learning hierarchies to identify students' misconceptions for some science concepts is advocated. The use of this model to identify misconceptions with respect to the performance of 'stoichiometric calculations' and 'conservation of mechanical energy' is described. A number of specific misconceptions, many of which are not readily identified by consideration of items testing the basic concept, are reported in each case. Suggestions are made for use of these misconceptions in conjunction with diagnostic testing and information processing.

Session J-3

VARIATIONS IN STUDENTS' SCIENCE KNOWLEDGE

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Ausubel has argued that understanding students' prior knowledge of a subject should be a major consideration in designing effective instruction. In order to follow this principle, however, the extent of variations in student knowledge must be understood. If the variations in students' knowledge are too extensive, then adequately considering prior knowledge in curriculum design becomes quite difficult.

In order to determine variations in prior knowledge, thirty-one eleventh grade physics students were given clinical interviews related to heat transfer prior to instruction on that topic. Transcripts of the clinical interviews were analyzed to identify each unique proposition used by the students. The frequency with which each proposition was stated and a cluster analysis procedure was used to determine variations in the students' knowledge. The results indicated (1) a set of propositions common to nearly all students, (2) four substantial groups of students who shared distinctive sets of propositions, and (3) a moderate number of propositions that were essentially idiosyncratic.

The implication of the results is that teachers and curriculum developers can consider the commonly held student knowledge of a subject and the alternative conceptions of a limited number of groups of students in designing instruction. More effective instruction is likely to result when this is done. However, accounting for the additional knowledge that is particular to individuals must be done as it has been...by teachers interacting with students in their classes.

Session J-5

THE CONSTRUCTION AND VALIDATION OF THE TEST OF GRAPHING IN SCIENCE (TOGS)

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The objective of this project was to develop a multiple choice test of graphing skills appropriate for science students from grades seven through twelve. Skills associated with the construction and interpretation of line graphs were delineated and nine objectives encompassing these skills were developed. Twenty-six items were then constructed to measure these objectives. To establish content validity, items and objectives were submitted to a panel of reviewers. The experts agreed with the test developers on the assignment of test items to objectives 94% of the time, and on the scoring of the items 98% of the time.

TOGS was then administered to one hundred and nineteen 7th, 9th, and 11th grade students. Scores ranged from 3 to 24 correct (X = 13.8 s.d. = 5.2). The overall reliability (KR-20) was .81. Poorly functioning items were rewritten and the revised version of the test was given to 387 - 7th through 12th grade students. Total scores ranged from 2 to 26 correct (X = 13.5 s.d. = 5.4). The reliability (KR-20) was .84 for all subjects and ranged from .71 for eighth grade students to .88 with ninth grade students. Point biserial correlations showed 24 of the 26 items above .30 with an average value of .43. Thus, it was concluded that TOGS was a valid and reliable instrument for measuring graphing abilities.

Session J-5

AN EXAMINATION OF THE GRAPHING ABILITIES OF STUDENTS IN GRADES SEVEN THROUGH TWELVE

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Line graphs are a commonly used method for conveying information in a concise orderly fashion. They are extremely important in science because they allow one to display the relationship between variables. The objective of this study was to examine student competencies in the construction and interpretation of the line graphs.

Approximately 385 subjects in grades 7 through 12 were administered the Test of Graphing in Science (TOGS). TOGS is a 26 item, multiple-choice test for middle and secondary students with a reliability of .84 (KR-20). The items relate to two aspects of graphing skills, construction and interpretation. Total test mean scores ranged from 11.16 to 15.42. On the interpretation subtest means ranged from 4.89 to 7.25. For the construction subtest means ranged from 6.27 to 8.17. The percentage of questions answered correctly relating to any individual objective ranged from 31% to 82%. The objectives with the highest percent correct dealt with plotting points and determining the X and Y coordinates of a point. The objectives most difficult to master dealt with scaling axes and drawing a best fit line.

Ninth graders scores exceeded all others. This might be due to two possible factors. One is the curriculum or teachers might not have emphasized graphing skills until the ninth grade. Another possibility is ninth grade may span a critical time for learning graphing skills. These results suggest graphing skills should be introduced in earlier grades and be properly emphasized in the science and math curriculum.

ENHANCING THE VISUAL-SPATIAL APTITUDE OF STUDENTS

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Research to date has not been able to agree whether visual-spatial ability can be influenced through practice. Many have concluded that spatial awareness is an innate phenomena and cannot be learned (Smith, 1963; McFie, 1973). Others contend that an individual's visuo-spatial potentials are acquired through interactions with the environment. Many of these theorists believe that spatial thinking can be developed through interactive exercises devised to encourage mental image formation and manipulation (Brinkmann, 1966; DeBono, 1976). To help alleviate the confusion surrounding this question the following study was undertaken.

Eighty-four (84) college undergraduates were randomly placed into control and experimental populations. Student records were examined to assure that the populations did not differ significantly in their verbal or math proficiency and pertinent pretests were given to ascertain spatial levels. The populations were also similar on their male and female ratios.

During the semester the experimental population was treated to a thirty (30) minute interaction each week. These sessions involved spatial exercises that required the participants to mentally bisect three (3) dimensional geometric figures and to envision the shape of the two (2) dimensional surface formed by the bisection. The subjects drew their mental image of this surface on a sheet of paper.

Fourteen (14) weeks later both populations were post tested with a second comparable version of the pretest. Statistical "t" tests were performed on the group means to see if significant differences developed between the populations. The results indicate that statistical improvement in visuo-spatial cognition did occur for the experimental group in spatial visualization, spatial orientation and flexibility of closure. This finding suggests that the weekly intervention sessions had a positive effect on the students' visuo-spatial awareness.

When the results were examined for only those individuals classified as highly spatial (one standard deviation above the mean) or poorly spatial (one standard deviation below the mean) an interesting pattern was observed. The experimental highly spatial subjects were seen to significantly improve in their ability to manipulate a neural image (spatial visualization). Poorly spatial subjects in the experimental group, on the other hand, out performed their counterparts in image manipulation (spatial visualization) and the ability to ignore extraneous information (flexibility of closure).

These results, therefore, tend to support those researchers that claim visuo-spatial aptitude can be enhanced through teaching. This study has found that the cognitive capacities for spatial visualization, spatial orientation, and flexibility of closure can be improved through carefully designed interactions.

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USING ANALOGS TO DETERMINE CHEMISTRY STUDENTS' SKILLS FOR SOLVING MOLE CONCEPT PROBLEMS

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This study was conducted to determine which skills and concepts high schools have that are prerequisites for solving moles problems through the use of analogs. Two analogous tests with four forms of each were prepared that corresponded to a conventional moles test. The analogs used were oranges and granules of sugar. Slight variations between test items on various forms permitted comparisons that would indicate specific conceptual and mathematical difficulties that students might have in solving moles problems. Different forms of the two tests were randomly assigned to 332 high school chemistry students of five teachers in four schools in central Indiana. Comparisons of total test score, subtest scores, and the number of students answering an item correctly using appropriate t-test and chi square tests resulted in the following conclusions: (1.) The size of the object makes no difference in the problem difficulty. (2.) Students understand the concepts of mass, volume, and particles equally well. (3.) Problems requiring two steps are easier than those requiring one step. (4.) Problems involving scientific notation are more difficult than those that do not. (5.) Problems involving the multiplication concept are easier than those involving the division concept. (6.) Problems involving the collective word "bag" are easier to solve than those using the word "billion." (7.) The use of the word "a(n)" makes the problem more difficult than using the number "1."

Session K-1

PROBLEM SOLVING AND PHYSICS INSTRUCTION

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Two types of conditional reasoning tests were administered to 105 high school seniors taking physics to determine the relative importance of linguistic encoding and logic abilities in solving problems. Conditional evaluation tasks which involve the ability to linguistically encode were used along with conditional syllogisms which involve the ability to linguistically encode as well as the ability to relate logical components from the syllogism. The P.S.S.C. and Dannings-Abeles Physics Tests representing different levels of conceptual understanding were also administered to the subjects. The responses to the conditional reasoning and physics tests were both reduced to factor components and then correlated with one another. Factors from both types of physics tests were predominately related to linguistic encoding factors, suggesting that solving problems at the introductory level involves predominately linguistic-encoding. Logical ability appeared to play only a minor role at this level. The linguistic encoding appears to involve a search process in which the information in the problem is related to some preexisting representation or algorithm. Once an association is made, a response is generated.

Session K-1

THE EFFECTS OF USING TWO- AND THREE-DIMENSIONAL MODELS ON SCIENCE ACHIEVEMENT OF STUDENTS WITH VARYING LEVELS OF SPATIAL ABILITY, COGNITIVE DEVELOPMENT AND GENDER

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This study was designed to assess the effects of three instructional strategies (treatments) on the immediate and retained achievement of biology students studying Homeostasis, DNA/Protein Synthesis, and Mitosis/Meiosis. The three treatments involved the dimensionality of the instructional aids and materials used to enhance lectures on the three topics of study. One treatment used only two-dimensional materials such as diagrams, pictures, or 2-D models; one treatment used only three-dimensional materials; and one treatment used a combination of both two- and three-dimensional materials. In addition, the subjects were evaluated for their levels of cognitive development and spatial visualization ability and also were categorized as to gender.

Data analysis procedures, with SCAT verbal and math scores utilized as covariates, were used to identify treatment effects as evidenced by achievement scores and to identify the main effects of cognitive development, spatial visualization ability, gender, and their interactions. These techniques were also used to identify the aptitude and gender by treatment interactions.

The following conclusions were drawn:

1. The combination of two- and three-dimensional instruction appeared to have been the most effective strategy.

2. Formal operational students tended to score significantly higher than less-than-formal operational students.

3. Spatial visualization ability had little relationship with achievement.

4. Females tended to score higher than males.

5. The effects of treatment on achievement across (a) cognitive development, (b) spatial visualization ability, and (c) gender appear to have been consistent.

6. In general, the achievement of students of varying levels of cognitive development tended to be consistent across gender.

7. The achievement of students of varying levels of spatial visualization ability appears to have been consistent across gender.

Session K-3

YOUNG CHILDREN ASK OPERATIONAL QUESTIONS IN SCIENCE

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Alfke's (1974) operational questions: 1) are concerned with cause and effect relationships; 2) imply action on the part of the student; and 3) lead students to seek answers from evidence.

The basic question to be answered was: Can the frequency of operational questions asked by fifth and sixth grade students be increased by varying the method of science instruction?

The dependent variable was the number of operational questions asked by students and the three treatments were:

T_1 - Teacher modeling of operational questions

T_2 - Teacher modeling plus written practice

T_c - Filmstrips and teacher exposition with no mention of operational questions

Seventy two students were randomly assigned to the three treatment groups for the three-week treatment period. Three teachers were randomly assigned to the three treatment groups.

The pretest and posttest was the number of operational questions each student could write in a five-minute period following a science demonstration by the teacher. The questions were classified as operational or non-operational by a jury of teachers trained to categorize the questions, teachers not involved in the study.

The three treatment groups were equivalent prior to the experiment as indicated by similar mean scores on the pretest. On the posttest:

1. T_1 T_c 2. T_2 T_c 3. T_2 T_1

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Allison, A. Wayne. "A Comparison of Two Methods of Teaching Fifth and Sixth Grade Students to Ask Operational Questions." Unpublished dissertation. The Pennsylvania State University, 1982.

Session K-3

THE RELATIONSHIP AMONG STUDENTS' QUESTIONING LEVEL, THEIR COGNITIVE LEVEL, AND TEACHER'S QUESTIONING LEVEL

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An experimental case study was conducted to investigate the relationship among students' questioning level, their cognitive level, and their teacher's questioning level. The Question Category System for Science (Blosser, 1970) was used to identify levels of questions asked by three teachers and their students during their science classes, where SCIS or ESS materials were being presented. A Piagetian task analysis was administered to students and teachers to establish the operational level at which they were functioning. It was proposed that cognitive-memory and convergent questions require concrete-level thought, and that divergent and evaluative questions require formal-level thought. Questions asked by students and teachers in the three sixth-grade classrooms were classified according to level and tallied for the period of one science unit. The teachers were then trained to increase their use of higher level questions by reading the self-instructional text, The Handbook of Effective Questioning Techniques (Blosser, 1970). Observations to classify and tally questions posed by the teachers and their students were conducted again for the duration of another science unit.

This study found that students modeled their teachers in the level of questions they asked. In addition, concrete-level students asked more formal-level questions after teachers had been trained to increase the proportion of higher-level questions they asked. It is suggested that another study might be conducted to test the theories of Vygotsky against the findings of this study.

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Session K-3

A STUDY OF THE EFFECT OF THE NUMBER OF PROPERTIES IN A DECISION MAKING SITUATION ON THE NUMBER OF ALTERNATIVES GENERATED BY YOUNG CHILDREN

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Recent research into the effects of decision making skill and the ability of students to guide their own learning strongly supports the development of pedagogy designed specifically to teach children the skills requisite to rational decision making. At the present time, however, little is known about how children in the primary school years generate or identify multiple alternatives, how decision making skills are developed, and how rational decision making can be taught. The primary objective of this study was to investigate one aspect of decision making; how variances in the number of properties in an object collection influence the ability of children to identify multiple alternatives.

A post test only design was used with second and fourth graders randomly assigned to three decision making treatments. In the treatments the Ss were asked to make an award to two children who had tied for first in a contest. The objects to be used for the award were sacks of jelly beans. The treatments varied in the characteristics (color) of the jelly beans in the sacks. The number of different colors varied across treatments. (Treatment 1 - one color, treatment 2 - 5 colors, and treatment 3 - 7 colors).

Analysis of variance of the data suggest that variances in object properties result in an increase in number of alternatives a student generates in a concrete object centered episode. Specifically, this indicates a direct/positive and significant relationship between the number of properties of an object presented to a student in second and fourth grades and the number of alternatives named for a fair distribution of the objects. In addition it was found that second graders named more alternatives than did fourth graders.

Session K-4

FACTORS THAT INFLUENCE THE SCIENCE LEARNING OF EIGHTH GRADE STUDENTS IN SANTA CATARINA STATE (BRAZIL) PUBLIC SCHOOLS

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The lack of an overall external evaluation system in the State of Santa Catarina, the number of students, the amount of financial resources expended on the educational system in general, and science education specifically (because of specially prepared classrooms, i.e., laboratories, laboratory materials, outdoor facilities, etc), and the need to better understand the learning process, raise the need for an objective external evaluation process to examine the status quo of science education. As seen in the literature, researchers have discovered that cognitive science achievement can be influenced by a complex set of independent factors; and this study examines the general picture of science achievement at the eighth grade level and how some of those independent factors actually work in a setting like the schools of Santa Catarina.

Session K-4

THE INFLUENCE OF PREFERRED AND ACTUAL INSTRUCTIONAL STRATEGIES ON THE COGNITIVE GROWTH AND ACHIEVEMENT IN BIOLOGY

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This study uses a quasi-experimental design to investigate the long-term effects of preferred and actual instructional styles of 2 preservice science teachers on the cognitive growth and biology achievement of 80 high school students in Nigeria. Four Piagetian formal tasks, a Science Teacher Ideological Preference Scale and a biology achievement test constructed and validated by the author were the instruments used in the study. Data collected in the study were analyzed by one way ANOVA, the results of which showed that both instructional methods enhanced cognitive growth and achievement in biology among the students. Compared to the results obtained in studies of this kind subjects in the present study appeared to be cognitively more ready to profit from instructional types. In view of the many variables intervening in the teaching learning process, further research should be conducted on the long-term effect of different instructional strategies on cognitive growth and science achievement in general among subjects whose learning styles are matched with respective teaching strategies. Results of the study also imply that teachers should, as far as possible, be introduced to as many different instructional strategies as there are.

Session K-4

RELATIONSHIPS BETWEEN MOTIVATION AND ACHIEVEMENT OF 17 YEAR OLDS IN SCIENCE

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Teaching is a dynamic interaction, requiring careful analysis and planning of action to make learning more probable and predictably successul. Motivation is an important property within this action, involving processes which arouse, direct, and sustain student learning. It is expected, however, that motivators differentially interact with students' prior schooling experience, culture, and family attitudes. In attempt to identify these differences, questions in the affective and cognitive area from National Assessment of Educational Progress, Booklet 4, were subjected to a secondary analysis. The result included the identification of two different sets of factors or motivators, one for boys and one for girls. Each set of factors accounted for different amounts of achievement, ranging from 20.5% to 18.5% for boys on comprehension and application, and from 14.6% to 18.6% on comprehension and application questions for girls.

Session M-1

SECOND YEAR RESULTS OF THE EVALUATION OF AMUSEMENT PARK PHYSICS

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The Informal Science Study is funded by the National Science Foundation to develop instructional materials for middle-school and high school science and mathematics students. Specifically, the IfSS materials are designed to provide introductory, supplemental and advanced instruction in the areas of motion physics by focusing student attention to science and mathematics within informal settings, such as sport arenas, playgrounds and amusement parks.

In 1981-82, the second year of a three-year funding period, five instructional mini-units (designed for two day - three week time periods) were developed and pilot tested in three sites: Houston, Texas; Kansas City, Missouri; and Hershey, Pennsylvania. In all, some 70 teachers and 5,000 students, grades 5-12, were involved in the pilot testing. The five instructional mini-units are designed around student dialogue, providing introduction and review of physical science concepts in low key, non-technical language. Physical science terms are introduced, as they are needed in explaining real world experiences. In addition, several of the units entail the use of laboratory experiences using toys (race tracks, model rockets...) amusement park field trips (roller coasters...) and the study of sporting activities.

Pre- and post-testing of students in the 1981-82 field testing focused on four major variables:

1. Student recall of past experiences in informal settings.
2. Student knowledge of physical science terms/concepts/principles.
3. Student ability to apply physical science terms/concepts/principles to new problem settings.
4. Student attitude toward science.

Detailed in this paper set are six studies. For each of the studies the dependent variables are the four identified above. Specifically the studies report:

a. The degree to which classroom instruction focused on positive student experiences and influenced student attitudes toward science as well as increases in knowledge and application of science concepts.

b. Pre- and post-achievement differences between males and females on tests of experience recall, knowledge and comprehension of science concepts as well as attitudes toward science.

c. Pre- and post-achievement differences between urban, suburban and rural populations on tests of experience recall, knowledge and comprehension of science concepts as well as attitudes toward science.

d. The relationship between the level of teacher concern about the IfSS materials and the achievement of students studying the materials.

e. The degree to which actual park experiences enhance in-class learning of IfSS instructional objectives. In other words, what per cent of the variance of student learning can be attributed to the inclusion of field trips to amusement parks.

f. Physiological reactions of students to in-park learning experiences and a discussion of the effect of these reactions in concept acquisition.

Session M-2

RESEARCH WORKSHOP

USING RECENT RESEARCH METHODS BASED IN COGNITIVE PSYCHOLOGY TO EVALUATE SCIENCE TEXTBOOKS

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The three-fold purpose of this seminar/workshop is: (1) to present recent research findings and theoretical considerations described by cognitive researchers querying problems in reading and language, (2) to argue in a "workshop" fashion that their research works provide a reasonable basis for generating specific guidelines useful to teachers evaluating science textbooks and (3) to discuss in a "seminar" fashion the implications of these findings and considerations in light of research problems and issues in science education.

Copies of research reviews, guidelines for evaluating science textbooks and sample materials from textbooks will be available and will form the basis in part for this seminar/workshop. In addition, a discussion among the participants will focus on recent work done in cognitive psychology as it relates to learning and instruction in science education.

Session M-3

A NEUROMATHEMATICAL MODEL OF HUMAN INFORMATION PROCESSING AND ITS APPLICATION TO SCIENCE CONTENT ACQUISITION

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Although considerable advances have been made in the application of neuroscientific research knowledge to our understanding of some basic cognitive functions, we are far from understanding how particular neural structures or specific neurophysiological events mediate many of the cognitive processes of interest to educational practitioners. Sufficient neuroscientific information is available, however, to suggest that some processes of information acquisition in short-term memory can be modelled as a set of time-dependent equations representing rates of central nervous system activity. Three differential rate equations representing components of information processing are integrated and combined to yield a generalized equation. A plot of the function yields a theoretical learning curve that can be compared to experimental data as a test of the predictive accuracy of the model. Experimental data obtained from three classes of students and three treatment communications correspond very closely to the predicted values. Insights gained from an analysis of the model are applied to theoretical and practical questions in science learning including: (1) the effects of content organization in memory on immediate rates of science content acquisition, (2) the significance of active attention interval and short-term memory encoding capacity on the length and temporal phasing of science content, and (3) the maximum information carrying capacity that can be expected for students of varying intellectual ability.

Session M-3

CORRELATES OF CEREBRAL HEMISPHERICITY

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Variations among individuals in their ability or predisposition to learn is intriguing, yet at the same time, troublesome for the classroom teacher. There is no question that individual differences exist--every teacher encounters them routinely. What is puzzling, however, is what is the source(s) of the dilemma.

Four factors will be examined by this study; each having been proposed as sources of significant variability in learning by previous research. These are cognitive ability level, learning style, learning disabilities, and gender. The manner in which these will be examined is not to verify them as sources of individual variability, but to examine the probable correlations between them and cerebral hemisphericity. Previous studies suggest, though not always with empirical data, that hemisphericity might account for substantial amounts of the variance as applied to these variables.

This study seeks to examine these variables among biology students in a suburban high school of Atlanta, Georgia. The sample size will be approximately 300, and assumed to be random since all of the sophomores at this school take biology. A special subsample of 40 students identified by testing as having learning disabilities related to language useage (verbal, reading, etc.) will also be utilized.

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Session M-3

NEUROSCIENCE AND SCIENCE EDUCATION - IS THERE A LINK?

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A good deal of information has been generated recently in the area of whether or not there are implications for teaching and learning emanating from brain research. A wealth of information has been generated by neuroscientists in the past several years on possible learning and memory traces and on varying functions of the right and left brain hemispheres. A problem area exists in attempts to translate these findings into educational theory and practice too quickly.

There does not appear to be a direct link between neuroscience and education at this time, but there is potential to derive worthwhile paradigms and procedures for educational research. The authors will present information on networks of neuroscientists, cognitive scientists, and educators which are currently active, on relevant conference proceedings, and on the learning and memory research occurring in one major psychobiology laboratory. The authors' aim is to stimulate group discussion and encourage interested parties to contribute to a link between neuroscience and education.

Session M-4

THE EFFECT OF A WRITTEN PERSUASIVE COMMUNICATION ON THE ATTITUDES OF PRESERVICE ELEMENTARY SCHOOL TEACHERS

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The basic questions asked were:

1. Will a written persuasive communication modify the attitudes of preservice teachers toward the teaching of simple chemistry concepts?

2. Will the change in attitudes, if any, be retained three weeks later?

3. Will the persuasive communication affect differently subjects on three levels of self-esteem?

The independent variables were three levels of self-esteem and two types of communication, experimental and control. The dependent variables were the attitude change at posttest and the persistence of attitude change at post-posttest.

Ninety eight subjects were divided into three levels of self-esteem, and then assigned randomly to the two treatment groups. The experimental treatment consisted of a written message on the importance of teaching simple chemical concepts to elementary school children; the communication for the control group dealt with sleep and dreams.

The instruments were the Revised Jone-Field Feeling of Inadequacy Scale and the Hassan Chemistry Attitude Scale. Both scales were administered as pretests. Following treatment The Chemistry Attitude Scale was administered again as a posttest and finally as a post-posttest.

The results of the study were:

1. A written communication can modify the attitudes of preservice elementary teachers toward the teaching of simple chemistry concepts in the elementary school.

2. The effect of the experimental treatment was not retained three weeks later.

3. The experimental treatment did not affect the three self-esteem levels differently.

REFERENCE

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Session M-4

CORRELATIONS OF SCIENCE PROCESS UNDERSTANDINGS WITH COGNITIVE DEVELOPMENT AND OTHER ACADEMIC VARIABLES AMONG PROSPECTIVE ELEMENTARY TEACHERS AND UNIVERSITY SCIENCE MAJORS

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Purposes of the study included the question of whether correlations exist between Test of Science Processes achievement and Test of Logical Thinking scores, along with six other independent variables, for two groups of prospective elementary teachers - early childhood and intermediate - and a group of college science majors.

Analysis of Variance was applied to test null hypotheses which dealt with whether differences existed between the three groups. Pearson Product-Moment Correlation analysis was performed to assess the degree of relationship between the dependent variable (TOSP) and each of the independent variables.

Significant difference in achievement on the TOSP was found between prospective early childhood teachers and college science majors. No significant differences occurred between prospective intermediate teachers and either of the other groups. Stepwise regression analysis indicated that Test of Logical Thinking, SAT, and grade point average are the best predictors of science processes achievement among the overall sample.

This study has significance for the preparation of elementary school teachers. In order to enhance discovery-inquiry techniques of teaching elementary children, greater emphasis needs to be placed on development of science process skills. Some science process and logical thinking tests should be used as diagnostic tools in elementary teacher preparation programs.

Session M-4

THE EFFECTS OF CONDUCTING A PRESERVICE ELEMENTARY SCIENCE METHODS COURSE BASED ON THE CONCERNS BASED ADOPTION MODEL (CBAM)

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This study assessed the effectiveness of conducting an elementary science methods course based on the Concerns Based Adoption Model (CBAM) upon the concerns and attitudes of preservice elementary teachers (PSTs). PSTs were randomly assigned to one of three treatment groups. Hypotheses were tested to determine if a traditional group or concerns based science methods course was more effective in improving attitudes or advancing PST concerns about teaching science. Three instruments - The Teacher Concerns Questionnaire, The Stages of Concern Questionnaire, and the Science Teacher Attitude Scales - were used to gather pretest, posttest, and delayed posttest data.

Analysis of study results indicated that both the traditional and concerns based science methods course significantly improved student attitudes and caused PSTs to have a positive shift from lower to higher stages of concerns about teaching science. Neither type of methods course proved superior in affecting student concerns or attitudes toward science and teaching science. The primary experimental group demonstrated more positive attitudes of the posttest.

Correlational analysis indicated that younger PSTs and PSTs with lower grade point averages had less positive science attitudes, fewer concerns about themselves, and more concerns about the impact on their teaching on students.

Session M-4

RESEARCH IN SCIENCE TEACHER EDUCATION: A REVIEW AND CRITIQUE

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A critical review of literature (N = 150) in science teacher education was conducted to identify the areas of research, trends over the last 10 years and prevalent methodologies. The major journals in science education provided the primary source of information buttressed by ERIC searches. The largest category resulting from the review included research using various approaches in preparing teachers to affect the skills, knowledge, and attributes of beginning teachers. The predominant paradigm was empirical-analytic where discrete variables were studied apart from the total context. Generally, success was had where specific attempts to train beginning teachers had been attempted. Most studies did not address the complexities of the process and for the most part ignored the social and political contexts. Recommendations include working toward a more liberal methodology, seeking a more substantial and meaningful conceptualization, and addressing questions associated with goals, the political and social context, and the effectiveness of program elements.

Session M-5

DISJUNCTIVE REASONING OF STUDENTS AT AN URBAN COMMUNITY COLLEGE

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A preliminary study by the author focused on the difficulties with logical reasoning exhibited by pre-nursing and nursing students at an urban community college. Further analysis of the errors encountered using the disjunctive operator was performed. The disjunctive operator can be used in the inclusive or the exclusive form. Mixed truth forms caused difficulty in both inclusive and exclusive disjunctives.

Factor analysis and correlational studies show that reasoning tests are not related to the NLN pre-nursing scores or subscores. The NLN test is not testing for ability to reason. The significance of this statement is profound since one expects that people in the nursing profession are daily encountering important tasks that require higher level reasoning.

Session M-5

CHANGES IN MEDICAL STUDENTS' PERCEPTION OF THEIR ABILITIES AS DETERMINED WITH A DEFINED RANKING SYSTEM

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The Department of Family Medicine is responsible for a major portion of the undergraduate's education at the University of North Dakota School of Medicine. The Department is currently developing or revising several courses offered in a variety of locations. Due to the variance in location proper assessment of student performance presents a complex problem.

Previous student assessment was based on subjective evaluation forms. Thse forms used a scale which indicated the student performance was poor to excellent, one to five respectively. Because of the relative nature of this ranking system, it was difficult to obtain a clear picture of the student's ability. Therefore evaluation forms were developed that employed a defined ranking system.

A defined ranking system provides definition to the meaning of a particular rank. With this system it is possible to obtain a description of students ability before and after instruction and a comparision of student self evaluation and instructors evaluation. In addition a more descriptive picture of student's performance and their achievement of program objectives is possible.

This system was employed during the piloting of a trial three week program based in a rural hospital. The results indicate a growth in student ability, confirmed by instructor evaluation.

The use of defined ranks appears to provide a clearer picture of student performance. In addition, future research will provide an indication of their usefulness in the research of other program development variables and the development of other professionals.

Session M-5

A STUDY OF THE COGNITIVE AND SOCIAL DEVELOPMENT OF FRESHMEN AND SENIOR MEDICAL STUDENTS

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The purpose of this study is to explore the development of logical thinking and social awareness in medical students, using methods derived from and compatible with the developmental learning theory of Jean Piaget. Questions concerning developmental growth during the medical school years, the relationship between development in the cognitive and social domains, and the choice of clinical/academic careers are the focus of this study.

Randomly selected samples of first and fourth year medical students were given three of Piaget's logical thinking tasks and three paper and pencil social developmental instruments. Results reflect the growth during medical school in the areas of both logical thinking and social awareness. The results, especially those in the social domain, are compared to similar research conducted with medical students and residents.

These findings can be of significance for medical schools in the following areas:

1. Medical and pre-medical curriculum and instructional modifications which would facilitate greater attainment of higher intellectual developmental levels
2. Career counseling to assist students in choosing clinical or academic careers, and,
3. Improved selection of medical students supported by a greater understanding and use of the ideas of developmental learning theory.

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